The magazine of aerospace technology / JUNE 1959

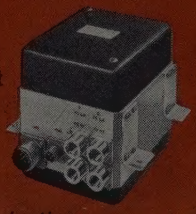
space aeronautics

FORMERLY AVIATION AGE

SPECIAL REPORT: **EUROPEAN AEROSPACE PROGRESS**

A CONOVER-MAST PUBLICATION

ADVANCED FUEL MANAGEMENT ...FROM SMI



The requirements of accurately tanking missiles with propellants is but one of the areas of fuel management in which Servomechanisms, Inc. has demonstrated capability. *Propellant utilization* and *thrust control* are other areas in which SMI has developed highly accurate and precise measuring and control systems.

SMI's LOX Tanking Computer, which has been in production for the past year, accurately measures, controls and indicates the level of liquid oxygen in missile tanks. Loading is accomplished rapidly and accurately due to a unique two-mode control system. The first mode permits extremely high pumping rates until about 98% capacity is reached. The second mode then takes over and controls a precise proportioning valve which adds the necessary LOX to fill the tank within 0.1% accuracy. The second mode also provides continuous topping, thus compensating for LOX evaporation losses during standby.

SMI has currently in development, more advanced fuel management systems to meet the increasingly complex requirements of the next generation of missiles and spacecraft.

SMI would welcome the opportunity to discuss and propose solutions to your fuel management problems. Write for descriptive literature.

Positions are available for qualified engineers and scientists in the areas of:
Systems Synthesis and Analysis—Project Management —Qualification and Environmental Test Engineering—High Vacuum Deposition Techniques.

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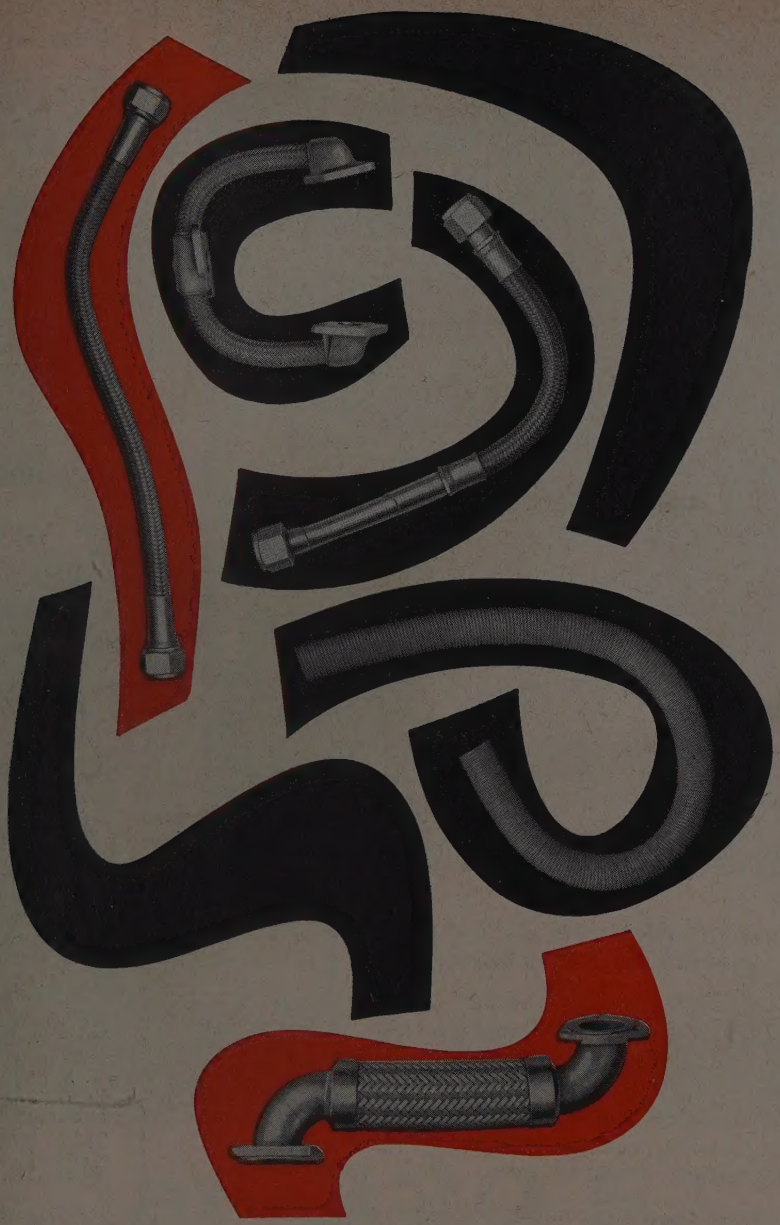
The products of SMI are available in Canada and throughout the world through Servomechanisms (Canada) Limited, Toronto 15, Onta



titeflex flexible hose made for the toughest design jobs

It is now possible to design fluid transfers that would have been impossible until recently. Here are examples of TITEFLEX advances in the flexible hose field:

ITEM: Springfield "400"* Teflon** hose in diameters to 2" . . . convoluted by an exclusive process to produce unique flexibility . . . minimum bend radius only 3⅓ times hose diameter!

ITEM: "Zero-motion" braiding . . . a TITEFLEX process that also reduces chafing of braid wire, and wear to minimum. Elongation or contraction at operating pressure less than ½ of 1%!

ITEM: Springfield "140" Teflon Hose Assemblies . . . with reusable fittings . . . factory or field installed!

ITEM: Springfield "110" Teflon Hose Assemblies . . . guaranteed against fitting blow-off at their specified temperatures and pressures!

TITEFLEX is found wherever design problems are toughest. Details and specifications are as close as your phone. Your TITEFLEX distributor is in the yellow pages, or contact TITEFLEX direct.

titeflex

*T.M. of Titeflex, Inc., Patent Pending **Reg. T.M. of duPont

titeflex inc. springfield mass. PACIFIC DIVISION • SANTA MONICA • CALIF

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project:
BUILDING COMMUNICATIONS SYSTEMS AT 60 mph

FRI's Flying Cable Cartridge allows complete network to be laid by helicopter

Previously, communications cable was fed out from uncontrolled reels. However, when the cable hit a snag, the reel fed out too quickly. The cable cascaded, tangled—or broke. Flight Refueling, Inc., in conjunction with ITT Laboratories, designed and manufactured a complete package that feeds the cable out smoothly, evenly . . . and fast . . . no matter how rough the terrain.

This is only one of the many controlled airborne suspension projects from FRI. Others include design study of equipment for towing targets at high speeds, trailing dip sonar systems and fire-fighting packages for transportation into stricken areas by helicopter.

If you have a problem in the area of controlled airborne suspension, Flight Refueling, Inc. has the facilities for the design, testing and manufacture of simplified, practical solutions. Write for literature.

Flight Refueling, Inc.

FRIENDSHIP INTERNATIONAL AIRPORT • BALTIMORE 3, MD.

West Coast Representative: William E. Davis, Box 642, Inglewood, Calif.

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space/aeronautics

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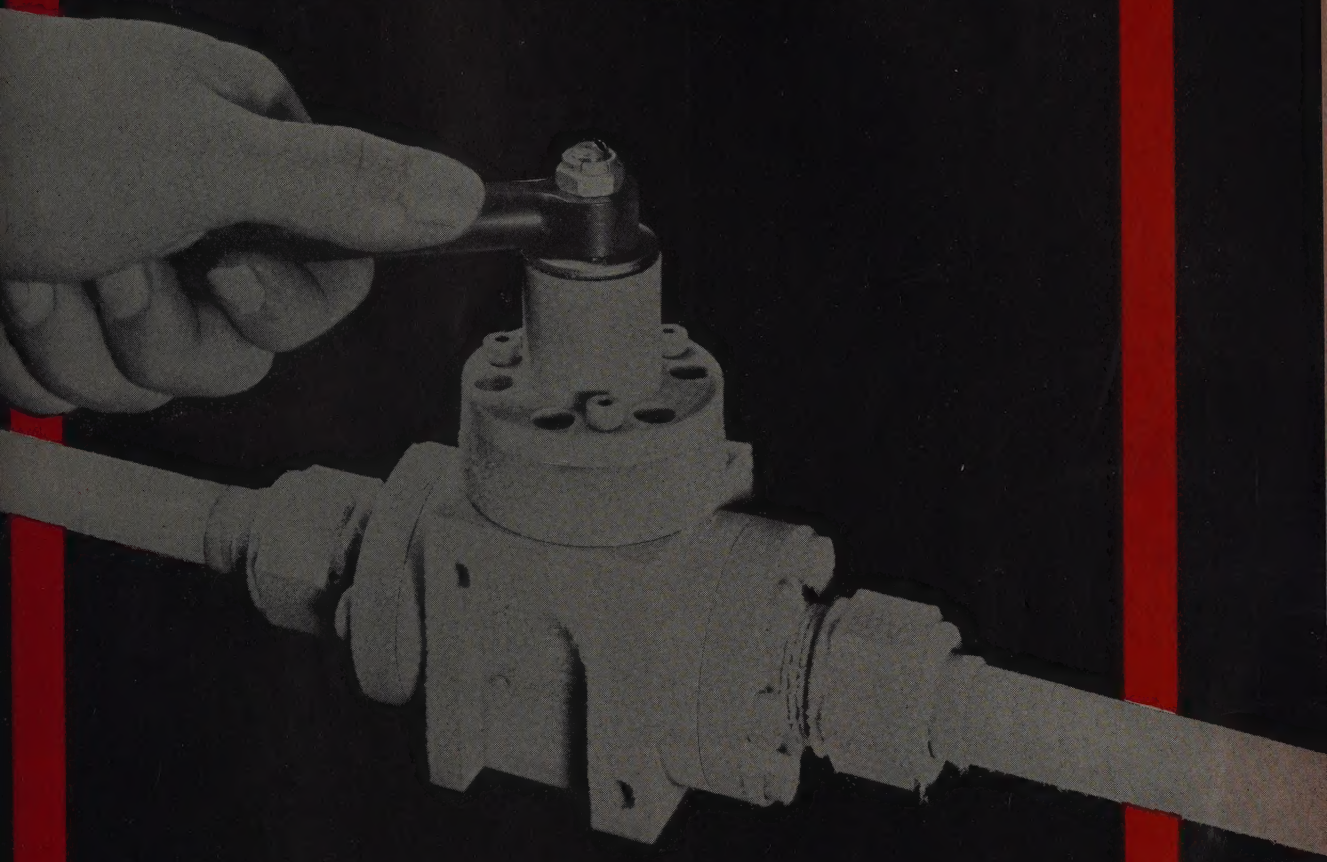
Barehand operation



...at -320°F.

Hydromatics *FLO·BALL* valves

Hydromatics valves are specifically designed to work at LOX temperatures . . . with minimum effort. Fast acting, ¼ turn operation, provides maximum reliability with bubble-tight sealing. Never any freezing problem. Hydromatics exclusive thermal barrier makes bare-handed operation possible at all times.

ALL *FLO·BALL* valves incorporate Hydromatics unique 100% flow efficiency characteristic.

From simple manual valves to complex propellant valves . . . Hydromatics makes them all. Write for complete information on *FLO·BALL* valves for high pressure, cryogenic, and corrrosive applications.

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FLO·BALL

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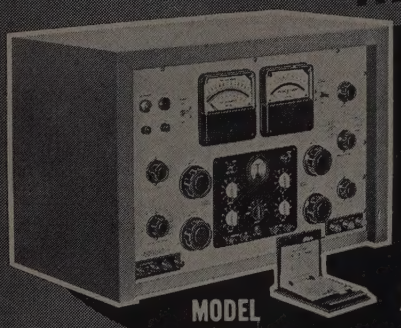
from
Instrument Calibration
HEADQUARTERS



a modern method of maintaining ACCURACY

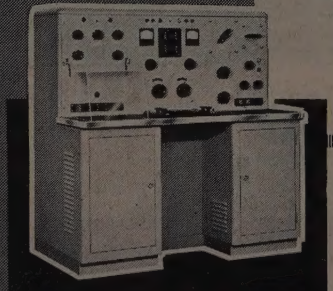
Superior and sustained quality control, through frequent calibration of test instruments, can be achieved by semi-skilled personnel using these self-contained standards.

Portable Model 829 calibrates both AC and DC meters over ranges from 0.25 millivolt to 2000 volts and 2 microamperes to 20 amperes. Direct reading accuracy of 1% (0.5% using charts supplied). Output frequency from 50 to 400 cps depending on line frequency used.

Net price $2,650.

Console Model 261B calibrates all types of AC meters to direct reading accuracies of 0.5% (0.25% using calibration charts) over frequency range of 50 to 1600 cps. Current range from 1.5 milliamperes to 200 amperes; voltage range from 75 millivolts to 1500 volts. Output of electronic power oscillator has less than 5% total harmonic content at 60 cycles.

Net price $9,250.



Model 262B Dual Potentiometer Standard calibrates DC electrical measuring instruments to direct reading accuracies of 0.1% (0.05% using calibration charts) through voltages ranging from 1 millivolt to 1500 volts and currents ranging from 1 microampere to 150 amperes. Employs Weston instruments and standard cells.

Net price $15,600.

Prices are f.o.b. Boonton, N.J. & subject to change without notice.

WE CAN HELP YOU

Technical and application data for our six basic models are fully described in a new 24-page catalog. Send for it today.

Radio Frequency LABORATORIES, INC.
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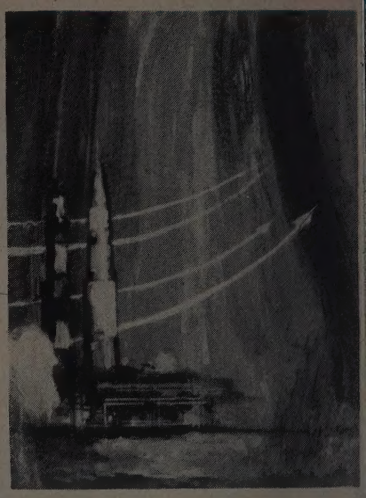
cover story



Europe's vibrant aerospace industry activities are covered by a special report beginning on page 38. The accomplishments are focused this month on the 23rd Salon International l'Aeronautique at Paris' Le Bourget Field, and are symbolized by George Meyerriecks' colorful painting on our cover.

No one can walk through the exhibition of products and equipment at the Salon without being impressed by the way ideas, techniques, and cooperation leap political boundaries. This tendency is increasing.

Meanwhile, the British government revealed that England will launch a "modest program" of space exploration in which British instruments will be sent aloft in U.S. vehicles.

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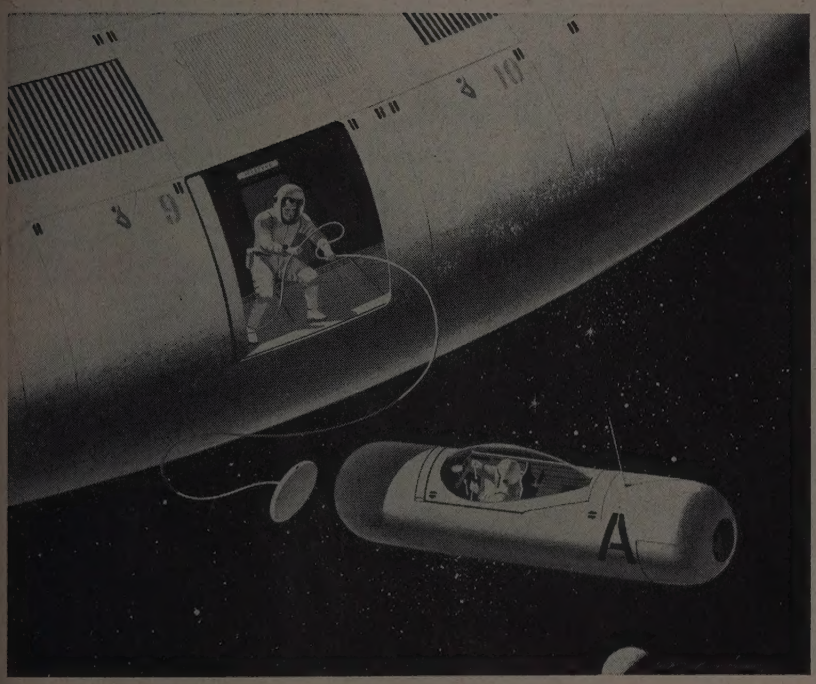
for the conquest of space



WHAT KIND OF ENGINE FOR A SPACE-JEEP?

It takes a unique engine to jockey a space-jeep in for a landing on an orbiting space station—one that will give a space pilot instant control and precise maneuverability.

Such an engine is the fully controllable rocket engine—ideal for space travel yet as easy to operate as an automobile engine.

The rocket engines are ready now

Although the space-jeep is still a gleam in an engineer's eye, the controllable rocket engine is available now...and has immediate application for existing aircraft. The pilot of a plane with auxiliary rocket power can switch it on for sudden, swift acceleration at high altitudes... the aircraft's air-breathing turbojets supplying power for ordinary flight operations. This is the mixed-power theory. Since World War II several mixed-power concepts have been developed in foreign countries, including Russia, France and England.

Extra power for today's aircraft

Rocketdyne already has designed, tested, and manufactured rocket engines for mixed power applications. The AR-1 rocket engine is a liquid-propellant system, as are the large power plants for the Atlas, Thor, Jupiter, and Redstone ballistic missiles. The AR-1 passed stringent flight tests as a supplementary power plant on modern jet aircraft. Substantial improvements over normal near-sonic speed and 50,000-foot altitude capabilities were demonstrated in more than 100 test flights.

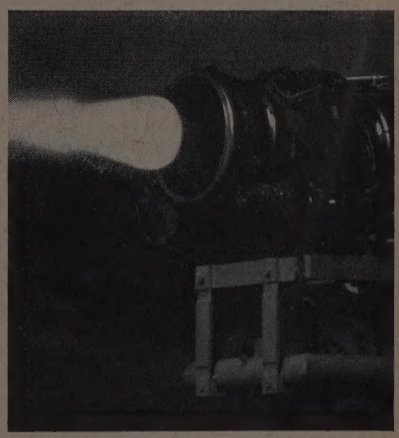
The AR-2, second in a series of four rocket-engine models developed by Rocketdyne, is a fully-throttleable engine that provides varied thrust. Using fuel from the airplane's tanks—which automatically ignites with hydrogen peroxide—these engines have full stop and restart capability.

More value for taxpayers' money

The auxiliary rocket engine gives present aircraft superperformance capabilities at a relatively low cost. It provides the increased speed and maneuverability that could spell the difference between the success or failure of an intercept mission. Almost any existing jet aircraft, as well as those now on the drawing board, can be adapted readily for AR engines.

Looking forward to tomorrow

Beyond a doubt, rocket power has a leading role in the Free World's future. Rocket-propelled airplanes, such as the X-15, will pave the way for man's entry into Outer Space. The multi-million-pound-thrust systems that are now under development at Rocketdyne will be man's means to explore interplanetary Space. But meanwhile, these rapid advances in rocketry can add great strength to America's present deterrent arsenal.



THE MEASURE OF ROCKET POWER

The liquid-propellant AR rocket engines are "static tested" at Rocketdyne's field laboratory to measure thrust and performance.

FIRST WITH POWER FOR OUTER SPACE

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.

June 1959

volume 31, number 6

space/aeronautics

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The editorial content of Space/Aeronautics is regularly examined for readability by Robert Gunning Assoc., counselors in clear writing. These consultants meet periodically with the editors and discuss comparative readability ratings.

Checking Regulus I surface-to-surface missile prior to launching from experimental cart. For the use of Ni-Cr-Mo steel castings in the launching cart, Chance Vought was judged a National Award Winner in the Third Product Development Contest conducted by the Steel Founders' Society of America.

How castings of 4330 nickel-alloyed steel help boost a missile up, push assembly cost down

20-Ni-Cr-Mo steel castings replace 73 detail parts, eliminate 300 hardware items in new launching cart

Regulus I, made by Chance Vought, is normally boosted skyward from a rail launcher. The Navy, however, wanted a more economical launching technique that would utilize a carrier's powerful catapults . . . that would also simplify handling of the missile aboard ship.

The answer was the expendable catapult cart you see above.

The carts, also made by Chance Vought, are assembled with 20 cast 4330 steel cluster joints welded to tubing of the same material. These castings replaced 73 detail parts required in the plate-type fittings of the experimental units used to prove the idea. They also eliminated 300 hardware items, such as nuts and bolts. Assembly is easier, and far more economical.

Why Ni-Cr-Mo steel for the castings? The 4330 composition of 1.8% Ni .65% Cr. .25% Mo heat treated to 125,000 and 150,000 psi gives these castings the combination of high strength and great toughness needed to stand up to the tremendous shock of take off.

What about your product? Can it use the economy, high strength, and shock resistance offered by Ni-Cr-Mo steel castings? You can get complete information by writing:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

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in this issue

Here's a quick rundown of the technical information offered in the articles in this issue. You can also use these article abstracts to build up your own permanent record for reference in the future—just clip them, paste them up on standard three-by-five cards, and file them.

European Aerospace Progress (Special Report)
Astia code: 1-2, -3, -9; 9-6, 7 12-1, -4; 27-2, -3
Your code:

STOLs and VTOLs highlight European progress

General review of technical development in West European missiles, aircraft, powerplants, and ground support equipment. Details are given on laminarization theories as applied to Handley Page HP-113 and on the jet flap principle.

by James H. Stevens, Technical Correspondent
space/aeronautics 31/6 (June '59) p. 40

European Aerospace Progress (Special Report)
Astia code: 5-2; 6-3, -6; 8-1, -2, -4; 19-3
Your code:

Aerospace electronics in Western Europe

State-of-the-art reports covering airborne radar, ground radar, guidance and control, airborne communications, infrared detectors, instrument landing systems, components and fabrication techniques, microwave generators, special computing equipment, and navigation equipment.

by Cyril C. Gee, British Communications & Electronics
space/aeronautics 31/6 (June '59) p. 47

Space/Aero Engineering
Systems Engineering, Dynamics, Structures, Propulsion, Accessory Systems
Astia code: 2-1; 27-3
Your code:

Booster design for a 20,000-lb satellite

Design study of a three-stage booster system based on current state of the art. First stage is recoverable. Detailed analysis of propulsion system, with breakdown of structure and propellant weights for all three stages. Cutaway diagram shows arrangement of components and critical weights and materials.

by S. B. Kramer and R. A. Byers, Lockheed Aircraft
space/aeronautics 31/6 (June '59) p. 52

Space/Aero Engineering
Systems Engineering, Dynamics, Propulsion
Astia code: 1-9; 27-2
Your code:

Rotor tip turbojets revive interest in large copters

Discussion of new helicopter designs, proposed by Hiller Aircraft, that use rotor-tip-mounted turbojets. Performance figures, sketches, etc., are presented, with particular emphasis on proposed prototypes of 60,- and 120,000 lb gross weight.

by Irwin Stambler, Associate Editor
space/aeronautics 31/6 (June '59) p. 56

Space/Aero Engineering
Systems Engineering, Structures, Production Engineering
Astia code: 12-1; 17-4, -6; 26-1, -6
Your code:

Thor's structure is thin-gage aluminum (Design Progress)

Production design study of Douglas Thor IRBM. Sketches, cutaways, and photos of production operations are presented. Use of aluminum in the structure is noted.

by Irwin Stambler, Associate Editor
space/aeronautics 31/6 (June '59) p. 61

Space/Aero Engineering
Propulsion, Systems Engineering
Astia code: 27-2, -3
Your code:

Choosing engines for supersonic target drones

First article in two-part series. Systems analysis of storable liquid bipropellant rocket and pyrophoric fuel ramjet. Data given on system weights at different speeds, altitudes, and endurances; maximum flight envelope for rocket engine for flights up to eight minutes; and R&D and operating costs.

by R. P. Reul, Radioplane
space/aeronautics 31/6 (June '59) p. 65

Space/Aero Engineering
Ground Support
Astia code: 12-3
Your code:

Design tips for cryogenic storage vessels

Review of design criteria as they affect performance. Shows degree to which capacity, working pressure, and allowable evaporation loss affect design and operational efficiency. Details several points to consider in matching vessel design specs to operational requirements.

by G. F. Sulfrian, Hoffman Labs.
space/aeronautics 31/6 (June '59) p. 79

Space/Aero Engineering
Production Engineering
Astia code: 26-1, -5
Your code:

Assembly line techniques for computer production

Review of production line at new General Electric Computer Dept. plant in Phoenix, Ariz. Tape-controlled Wire-Wrap and drill press operations, printed-circuit flow solder methods, and memory core assembly techniques are described.

by Irwin Stambler, Associate Editor
space/aeronautics 31/6 (June '59) p. 89

To make filing easier, each abstract is coded according to the Astia Distribution Guide. Copies of this guide are available from Armed Services Technical Information Agency, Arlington Hall Sta., Arlington 12, Va. There is also room on the abstracts for you to insert your own key if you use a special coding system.

Space/Aero Engineering
Human Factors. Astia code: 16-15; 25-1; 26-3; 30-4
Testing, Production Engineering Your code:

How to protect yourself against noise

Analysis of noise effects on hearing, work performance, and spoken communication. Acceptable noise levels are graphed and fundamentals of protective wall and door design are explained. Sound transmission loss curves are given for various wall and door configurations.

by Fortune Odend'hal, Jamison Cold Storage Door
space/aeronautics 31/6 (June '59) **p. 101**

Space/Aero Electronics Astia code: 8-3; 19-3
Your code:

Doppler VOR extends use of omniranges

Principles of Doppler omnirange are explained and compared with those of standard VOR. Design characteristics that make the system less susceptible to bearing errors are discussed. Results of recent performance tests are given in brief.

by James Holahan, Electronics Editor
space/aeronautics 31/6 (June '59) **p. 118**

Space/Aero Electronics Astia code: 2-1; 5-2
Your code:

What the designer faces in active satellite communications

Basic problems involved in the development of a 24-hour-orbit, active satellite microwave communications system. System requirements and state-of-the-art limitations relative to reliability, life, communication handling capacity are analyzed, as are the critical parameters of the launch vehicle, guidance and control, communication equipment, and power source.

space/aeronautics 31/6 (June '59) **p. 122**

Space/Aero Electronics Astia code: 2-1; 19-1
Your code:

Astro compass brings space navigation closer (Design Digest)

Design analysis of an advanced celestial navigation system. Design specs and performance characteristics are outlined. Photos and diagrams show the workings of the optical telescope positioned automatically by its own stable platform. A functional diagram of the overall system is given.

by Bernard Kovit, Associate Electronics Editor
space/aeronautics 31/6 (June '59) **p. 127**

Space/Aero Electronics Astia code: 8-3
Your code:

Target's radar cross-section controlled with TWT amplifier

Discussion of operating principles and basic design of Sperry SEE radar augmentor using linear amplification. Device consists of a traveling wave tube mounted in the target drone or aircraft. By adjusting the gain of the amplifier, various target sizes can be simulated. Gain is constant with range.

by Henry Prew, Sperry Gyroscope
space/aeronautics 31/6 (June '59) **p. 131**

Space/Aero Electronics Astia code: 8-2, -4
Your code:

Three pacesetters for tomorrow's aerospace electronics

Brief technical discussions of micromodules, silicon solid state circuits, and the nuvistor. Tables list the micromodular components and circuits developed so far. Solid state phase shift oscillator circuit, with component equivalents is shown. Nuvistor characteristics are listed.

by James Holahan, Electronics Editor
space/aeronautics 31/6 (June '59) **p. 135**

coming next month

WITH THE MERCURY "Astronauts" all picked out, manned space flight is rapidly coming closer. One of the most critical phases of the Mercury program will be discussed in a detailed design analysis.

A MISSILE'S electronics really is a whole series of separate systems. One of these "subsystems", on which little has appeared in the literature, will be covered in an extensive design and trend review.

IN HYPERSONICS, one of the worst roadblocks is the lack of adequate test facilities (since the old wind tunnels just won't do any longer). Among the few "new-era" test facilities is a hypersonic shock tunnel on which a report will appear next month.

coming soon

STAGES THAT WOULDN'T separate have caused quite a staggering number of missile aborts. SPACE/AERONAUTICS will analyze the design factors involved in this problem.

. . . What This Important News Means to You!

"Up to now, I've only dreamed of being able to use *pure* tungsten . . . now it's a reality." This is a typical reaction to the news of Fansteel's breakthrough in the fabrication of tungsten.

It opens endless possibilities for using tungsten in any number of products—whether it's a spectacular missile, or a down-to-earth consumer item. Now . . . tungsten—with its melting point of 6152° F., highest of all metals, with its terrific strength at high temperatures, with its outstanding density of .697 lbs./cu. in.—can be exploited to the fullest.

Because Fansteel can now fabricate *pure* tungsten into almost any conceivable shape by spinning, deep drawing, hot extrusion or forging, the design engineer can count on tungsten . . .

—for greater reliability and longer life
—for even greater miniaturization
—for highest strength at extreme operating temperatures

Want to explore the possibilities of adapting tungsten to *your* product? Fansteel engineers will be glad to work with you. Just send print, part sample or call in your Fansteel representative.

Only your imagination will determine what lies ahead in the uses of tungsten.

FANSTEEL
HIGH TEMPERATURE METALS

F393

FANSTEEL METALLURGICAL CORPORATION, NORTH CHICAGO, ILLINOIS, U. S. A.

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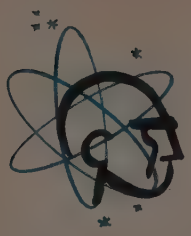

keeping in touch

Aviation industry becomes "aerospace" industry

"AEROSPACE" is now the official term for the industry served by SPACE/AERONAUTICS and our contemporaries. It was made official when the Aircraft Industries Association changed its name to "Aerospace Industries Association" on April 14. The change reflects what all experts in the field have been saying all along: that aircraft, missiles, and spacecraft involve the same basic technologies.

AIA's move followed 18 months or more of confusion. There was no agreement as to what the "aircraft" industry was, or what it was doing. Two publications even tried to read the old-time companies out of the party, as it were, and build up the myth of a separate missile industry. This despite the fact that the old aircraft firms had been deep in missiles from the start.

It became obvious, however, as the "aircraft" plants got their feet wet in missile work that the new beast—although using basically the same technologies—was outdating the word "aviation". When spacecraft got into the picture, it definitely was old hat.

Even government officials and agencies—not generally noted for readily accepting new concepts—have been referring cautiously to the "aerospace" industry.

What is the "aerospace" industry?

Well, what is the "aerospace" industry? AIA defines it as "those persons, firms, or corporations engaged in the business of manufacturing, buying, selling, and dealing in aircraft and astronautical vehicles of every nature and description (including but not limited to pilotless aircraft, guided missiles, rockets, and satellites, manned or unmanned), powerplants for aircraft and astronautical vehicles, and parts and accessories thereof of every kind and nature."

It will be seen from this that the "aero" part of aerospace remains an integral part, and a very lively part, of the industry. More people are going to need and use airborne vehicles of every description than they will need spacecraft for a long time to come, if not indefinitely. But "aviation" will apply now to the conventional aircraft, military and civil, used by the services, the airlines, and the business flying operators.

The "advanced" technologies, stemming from the older, apply (generally speaking) to the other two members of the aerospace triology—missiles and spacecraft. Certain specialized, predominantly airborne vehicles will use "advanced" technologies as well, but they will hardly be classed as conventional.

Technologies build industry together

The "cement" that binds the three together into the aerospace industry is composed of the technologies used in developing aircraft, missiles, and spacecraft. As a technical magazine serving the information needs of engineers in all three branches, we have found that about 50 per cent of the specialists in any one technology work on aircraft as well as on missile and spacecraft projects.

In keeping with the expanding, broadening base of our industry, the Federal research agency, NACA, was renamed the National Aeronautics & Space Administration (NASA). Meanwhile, the Institute of the Aeronautical Sciences already had changed the names of its organs, the *Aeronautical Engineering Review* and the *Journal of the Aeronautical Sciences*, to *Aero/Space Engineering Review* and *Journal of the Aero/Space Sciences*, respectively.

The same ferment is going on in the European industry, where missile and space projects are displacing more conventional vehicle projects.

Now that "aerospace" is settling down to the status of an acceptable label for the field which we serve, we are incorporating it in our logo, as may be seen on the cover—SPACE/AERONAUTICS is the magazine of Aerospace Technology. As before, it covers the research, design and development of aircraft, missiles, and spacecraft.

William L. Mass

Publisher

Complex machining was avoided on the T-38 canopy supports with castings of high-strength Ductaluminum.
U.S. AIR FORCE
56156
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DUCTALUMINUM CASTINGS TO MIL-C-21180A SAVE NORTHROP $1,500 PER T-38 JET

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Northrop's example proves that high-strength castings with guaranteed mechanical properties (in the *casting*) can be used in place of forgings, extrusions or weldments for structural parts at considerable savings to the manufacturer. Consider these advantages of castings: lower tooling cost, intricate design, cast-in lightening holes and bosses, and rigid, one-piece construction.

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*Higher properties can be guaranteed in castings with favorable design characteristics.

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LIGHT METALS DEPARTMENT
MAHWAH, NEW JERSEY

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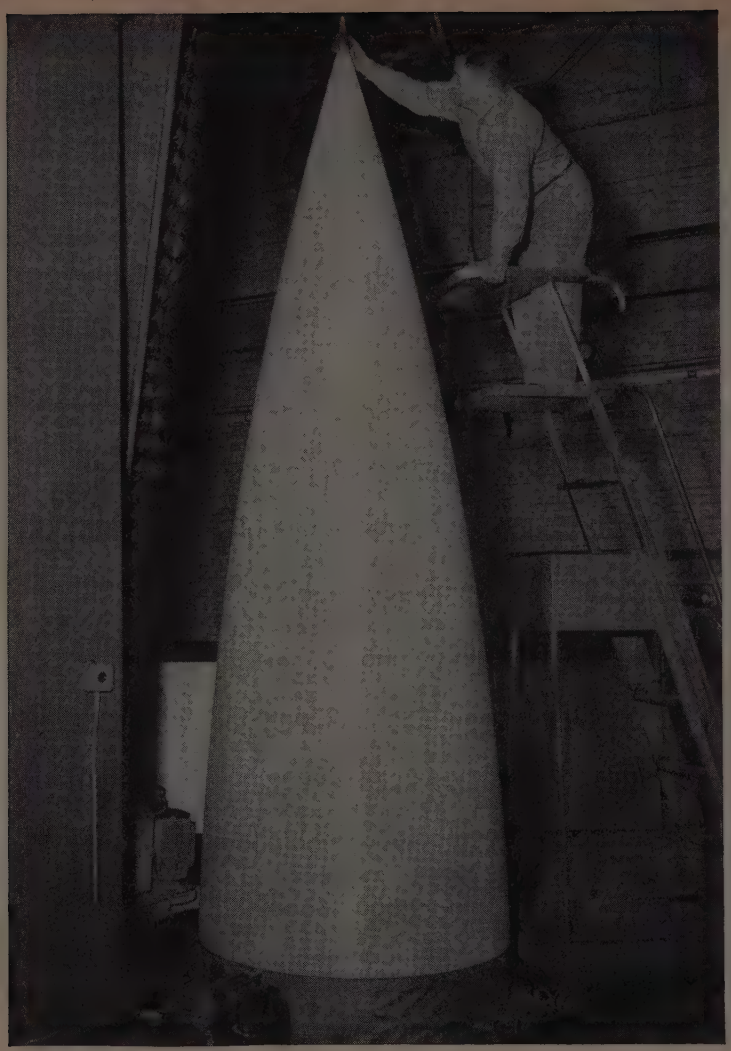

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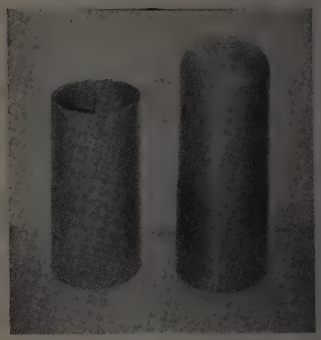
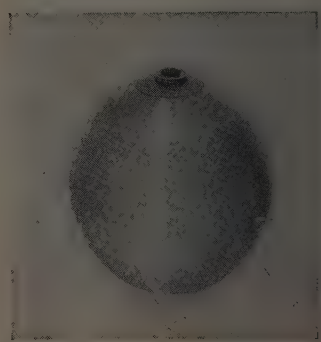
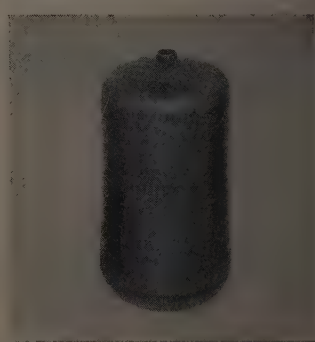


Thanks to Kidde's continuous winding process, a new field of fiberglass forms is now open to aviation engineers. Structural tubing, pressure vessels can now be made stronger than steel with half its weight!



For the engineer interested in the field of pneumatics, filament-wound fiberglass spheres offer the solution to many problems. Available in capacities of from 50 to 2500 cubic inches these spheres can withstand pressures up to 5000 psi.



Missile rocket motor cases, torpedo bodies and missile radomes are but a few of the forms which Kidde can fabricate from high-strength, low-weight fiberglass, capable of withstanding temperatures as high as 1000°F. for short periods of time.

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editorial

Europe's aerospace industry: prospects and problems

A NUMBER of cross-currents affect the course of Europe's aerospace industry. Mainly economic, these currents act (1) as a brake to industry growth; (2) as a stimulus to diversification and ingenuity; (3) as a cause for mergers.

A SPACE/AERONAUTICS survey brought to light some of the problems and prospects. The larger companies—particularly in Britain—are concerned over government policies that profoundly affect their future. Technical problems, to them, are of less concern. Smaller firms (those making equipment, accessories, etc.), on the other hand, are more absorbed in advancing the state of the art.

Because of government policy, big British firms find the demand for military aircraft is rapidly declining. The result has been a rash of diversification and mergers, or "combinations". The biggest prospects now seem to lie in missiles and the VTOL-STOL field. Excellent progress is being made in the latter.

In the civil transport field, there is strong competition, mainly from the U.S. Again, government policy, or the lack of it, complicates the British problem. Unless Whitehall backs supersonic (Mach 2.5-3) airliner development soon, British experts feel, their industry will lose forever its chance to compete in the long range market.

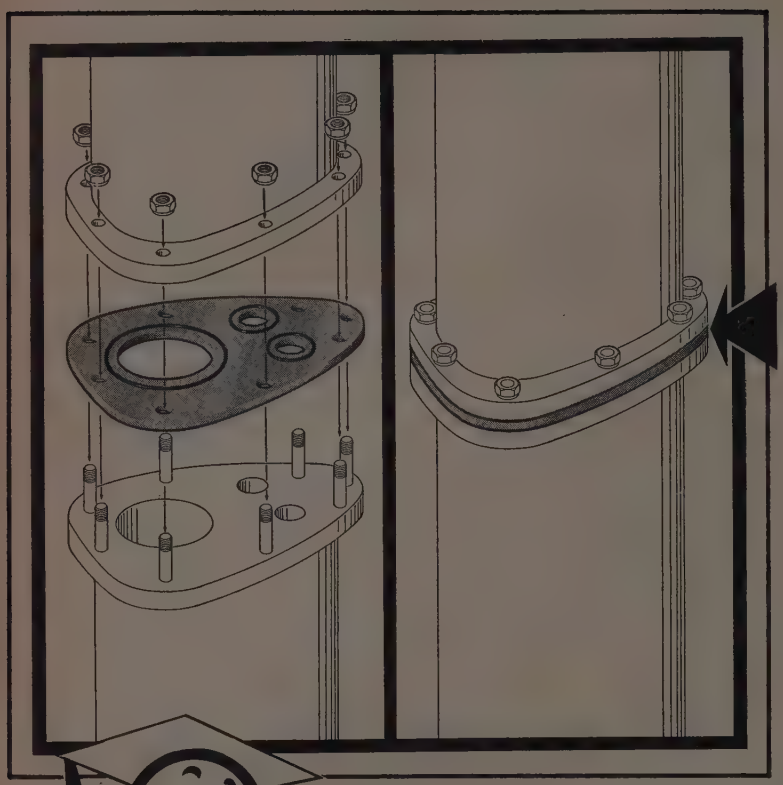
ON THE CONTINENT, however, little point is seen in building long range bombers or airliners. Leaders believe in leaving this market to the U.S. The tendency is to put the biggest effort into medium and short range aircraft. Sud-Aviation's Caravelle jet and SE 3200 heavy transport copter are typical examples.

A technico-economic problem is the state of European airlines. Cargo traffic is much less developed than in the U.S. Moreover, the rate of increase is declining. Freight operations are geared to whatever empty space is available in passenger aircraft. Plainly the Vickers Vanguard was designed to meet this problem. But cargo operations get little attention in fleet planning. This further limits the markets for the hard-pressed aircraft firms.

Generally speaking, however, business prospects are good. Most companies report their market is expanding, despite government policies. All are interested in getting U.S. research and development contracts, for which many are eminently suited technically. In addition, Europeans generally view their chances of breaking into the American home market as good. Indeed, many already have their products licensed to U.S. firms.

A growing factor in the whole economy of Europe is the common market, which includes France, Germany, Italy, Holland, Belgium, and Luxembourg. Britain's big chance there will be to supply its quality engines for many years to come.

Randolph Hawthorne, Editor



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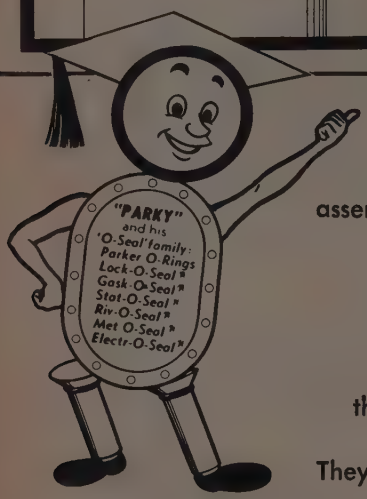

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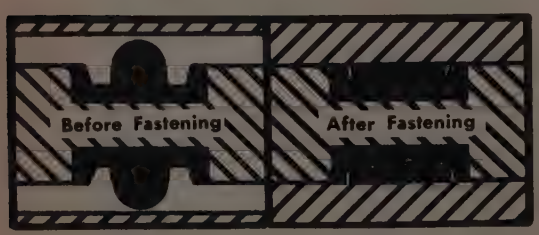

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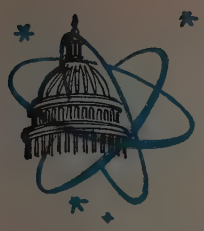

washington briefing

by **A. N. Wecksler,** Washington Bureau Chief

Planning for the missile gap

THERE is general agreement that in 1961 and 1962 there will be a missile gap, with the Soviets in the lead. But there is a sharp division on what to do about it. The Administration takes the position that the gap will be balanced by our manned bombers and other weapons. Congressional spokesmen are pressing for a crash effort to bring our missile strength to the fore, even though we have bomber deterrents.

For the immediate present, and for several years in the future, manned aircraft will continue to be the weapons at hand.

Tactical offense relies most heavily on the F-100 and F-105 fighter bombers, with the Matador and the Mace, the Corporal and the Redstone as supplements.

In air defense our reliance is on the F-102 and the F-104, plus the older F-89Ds, the F-86Ds, and the F-94Cs, supplemented by the Nike-Ajax and-Hercules, with the Bomarc coming in.

In SAC, it is the B-47s, B-52s, and a few B-58s, with something like a squadron of Thor IRBMs operational.

This is the picture as next month we go into fiscal 1960, when we will be spending some $6.6 billion for aircraft and $4.7 billion for missiles.

Obviously, the division in spending shows that we will continue to place the greatest reliance on manned aircraft. Some four years ago, a forecast was made that at some point in the future roughly 90 per cent of air defense could be taken over by missiles, 70 per cent of TAC, and 50 per cent of SAC.

These figures, if they were ever realistic, have been shoved off into the future.

As to some of our present attitudes toward manned aircraft versus missiles, SAC's thinking remains unchanged. SAC believes missile development should be pushed, but that bombers for the present and for the known future are a must.

In air defense, the thinking is that manned aircraft and missiles complement rather than displace each other. The Air Force position on the Bomarc and the F-108, both to be used for air defense, makes this clear.

The Bomarc is a high rate of fire, quickly reacting weapon system designed to operate initially at a range over 200 miles. The F-108, on the other hand, has longer ranges and relies on the flexibility and judgment of the human pilot. Identification is a requirement of air defense, and for the foreseeable future the F-108 will be used for this function.

In the field of tactical aircraft, the military takes the same position. For example the Air Force is evaluating the merits of a VTOL fighter with increased all-weather and strike-reconnaissance capability as a logical follow-on to the F-105.

As improvements in reaction time, deployability, and warhead effectiveness are achieved, increased use of missiles to supplement manned systems is expected.

The fighter bomber and the missiles, says the Air Force, complement each other as tactical warfare systems.

The Air Force doesn't see the Minuteman (unofficially forecast as operational by 1962-1963) as an answer to all ICBM problems, either. The Minuteman is not primarily being developed to meet tactical missile needs. But, out of research on it, there could be fallouts that would be applied to tactical operations.

The Minuteman, in the Air Force's view, will make air-breathing intercontinental missiles obsolete. It is anticipated that the Snark missile will be obsolescent by the time the Minuteman is available in quantity—and the Air Force does not have a specific air-breathing system to replace Snark.

Research is continuing in long range air-breathing missiles, and the door is not fully shut if improved air-breathing systems are developed.

In the ballistic missile area what the military does see are improved IRBMs and ICBMs beyond Minuteman. These will come out of the R&D work now in progress — but similarly there is a major R&D effort in manned aircraft.

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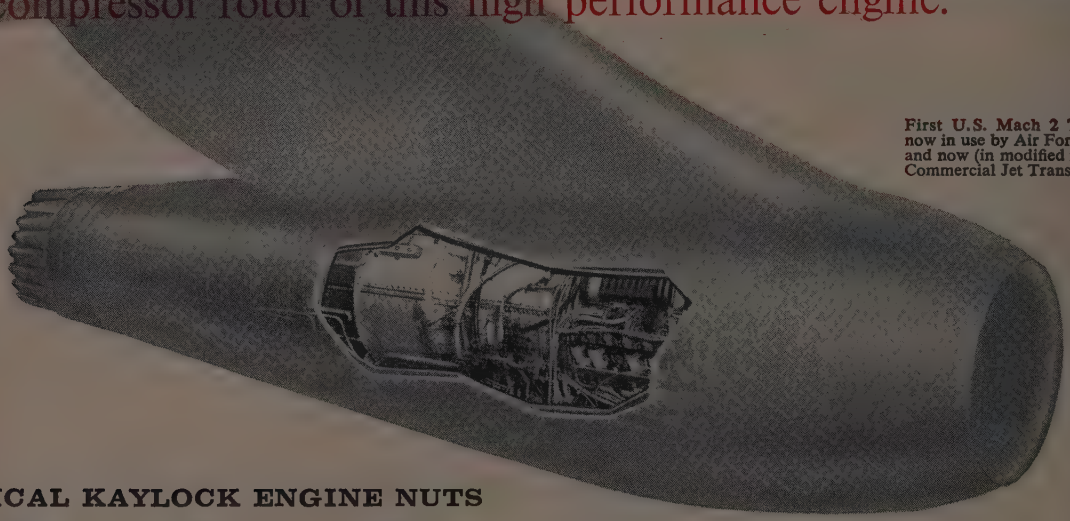

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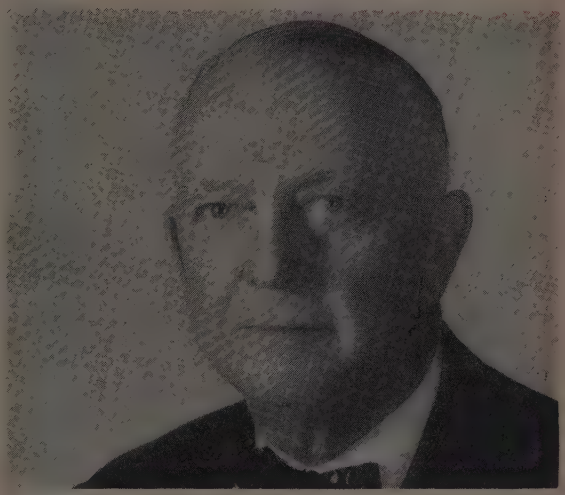
industry viewpoint

by **Robert M. Loebelson,** Associate Editor

The missile program must come first



DAN A. KIMBALL, President, Aerojet-General Corp.

THIS COUNTRY'S ability to survive in its battle with the Russians will continue to depend on superiority in nuclear weapons and the missiles to deliver them "for a long time to come." That's the viewpoint of Dan A. Kimball, president of the Aerojet-General Corp. and former Secretary of the Navy.

He believes that "we can't have too much military power in this country if we're going to keep the Russians at bay" and adds, "A large part of that power should be missile power, properly allocated to each military service according to its needs."

Kimball concedes that granting each service the right to have its own missile programs may result in some duplication of effort. "But I'm not so much worried about a little duplication here and there as I am about the chance of missing a good bet because somebody with a bright idea never gets the opportunity of developing it," he declares.

Aerojet's president also insists the U.S. must *now* find the money and brains to make certain this country is first in the race for space. And he maintains that the space effort and the missile effort are one and the same.

"Whether we call them satellites or missiles, they both have the same military implications," he states. "The 'peaceful' penetration of space or exploration of the moon or the planets is essentially a military venture, no matter what name you give it."

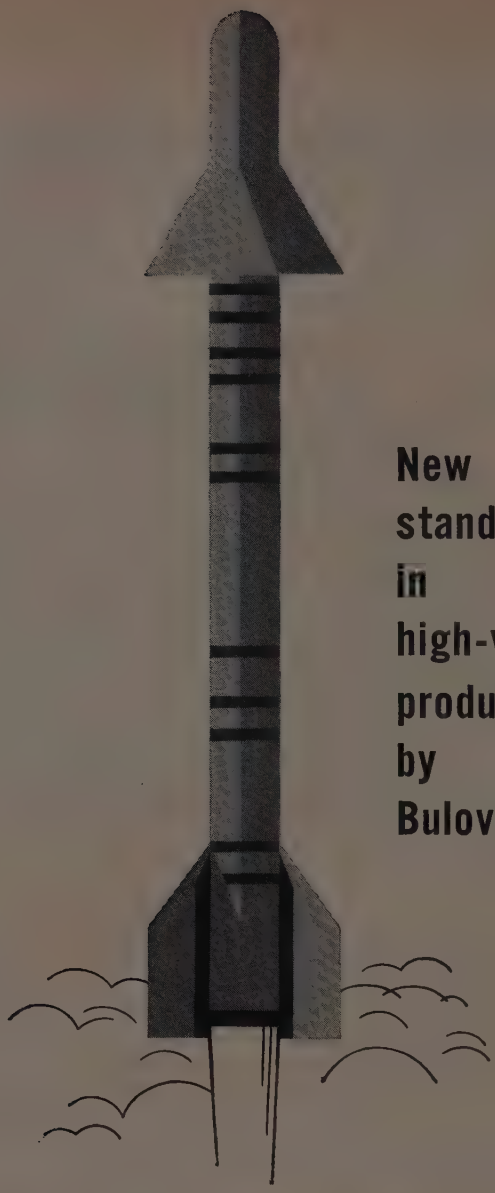
The one-time Navy Secretary asserts there is no valid distinction between "useful" military hardware and "useless" space exploration. "Both of them take the same kind of power, the same kind of vehicle, and the same kind of guidance," he points out. "Just as the airplane that could photograph could also bomb, so the satellite that can spy in orbit can be used for any military purpose we or the Russians desire. Let's not fool ourselves about that," Kimball emphasizes.

To get into first place in the space and missile contest, the U.S. must eliminate all possible loopholes. Says Kimball, "We've got to have missiles for every purpose—the very best we can make—and each of the services knows best what will best suit its particular purposes." The thing to avoid, he adds, is ending up with a static concept of either which missiles are to be developed or which service should use a specific "bird."

To get the best missiles, says the Aerojet president, "it may be necessary to take a long look at the Army, Navy, Air Force and Marines and see if they can't be organized even better on an overall basis to take full advantage of new discoveries and developments."

Kimball predicts that the long look at the services may have to come "sooner than we think." Because missiles are starting to take over missions formerly handled by manned airplanes, "we may have to decide what is strategic and what is tactical instead of what belongs to the ground forces, the naval forces or the air forces," he believes.

But until that day, he insists, the industry must supply each of the services with the best kind of hardware to help them handle their particular responsibilities. "We've got to have a complete arsenal of missiles, long and short range, for all the services. There can't be any second-class service or any second-class missile program for anybody."



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JUST AFTER choosing the French Nord SS-10/-11 anti-tank missile as standard equipment for its forces, the Army also picked Aeronutronic Systems to develop the new Shillelagh surface-to-surface missile for similar purposes.

The SS-10/11, a remote-controlled, wire-guided missile using a solid propellant will be produced by the thousands and will replace the Dart. First deliveries by Nord Aviation will go to the U.S. Seventh Army in West Germany.

THE SHILLELAGH, a lightweight missile, is to be used for close-in troop support against troops, armor, and field fortifications. Aeronutronic Systems will develop the new "bird" by assembling existing components. (However, Shillelagh is not considered an "off-the-shelf" missile.)

The total Shillelagh program is expected to come to $23 million, including $3 million in fiscal '59. Preliminary tests will be conducted in a few months. Operational status will be reached in the mid-'60's.

The electronic fire control system for the new missile is being designed by Raytheon's Santa Barbara, Calif., facility.

More R&D contracts to be let on Zeus, now favored as ICBM defense

WITH DEFENSE SECRETARY Neil H. McElroy and other Pentagon officials now convinced that the Western Electric-Douglas Nike-Zeus has the best potential against ICBMs "at this time," more research and development contracts to speed the Zeus are being let by the Army. Among recent awards given Western Electric were R&D contracts for $6.37 million, $9.95 million, and $8.67 million. Work will be handled by Bell Telephone Labs, Douglas (at Santa Monica, Calif.), Continental Can (at Coffeyville, Kans.), and Goodyear Aircraft.

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USAF OFFICIALS, including Military Air Transport Service personnel, are studying a Lockheed proposal for a beefed-up C-130 turboprop transport. The new airplane, which would use 65 per cent of the tooling for the C-130B present, would be powered by four Allison T61s (of 5500 hp each) and could be ready as early as '61.

The Super Hercules, fitting midway between the C-130 and the larger Douglas C-133, would carry 150 airborne troops or 116 paratroopers. In an airline configuration, it would seat 104.

AS A CARGO CARRIER, the Super C-130 could be operated commercially at 4½ cents per ton-mile and militarily at 2.9 cents per a ton-mile, Lockheed claims. The proposed plane, which would have a takeoff weight of 204,170 lb and cruise at up to 425 mph at 44,000 ft, would carry 25 tons across the Atlantic nonstop. For Pacific operations, pylon tanks would permit 16 tons to be transported 5500 miles nonstop.

Follow-on contracts to Bendix and Philco for Talos and Sidewinder

NAVY AWARDED more than $60 million in follow-on contracts for the air-to-air Sidewinder and surface-to-air Talos missiles.

Bendix Aviation got contracts totaling more than $41 million. They cover $28.3 million for production and $12.9 million for engineering and procurement of prototypes on Talos. The USS Galveston is already equipped with Talos, which will also be carried by six other cruisers, including the nuclear-powered Long Beach.

BuOrd ordered $13.5 million worth of infrared-guided Sidewinders from Philco. Another order of nearly $6 million went to the second source, GE-Utica.

•

USAF'S SELECTION of Douglas as the winner of its air-launched ballistic missile (ALBM) competition puts another major airframe company in a position to gain experience with solid propellants for large missiles. Other firms already in this area include Boeing (Minuteman), Lockheed (Polaris), Martin (Pershing), Sperry (Sergeant), and the major rocket producers, Aerojet-General, Rocketdyne, and Thiokol.

Douglas has had extensive experience with solid rockets for smaller missiles, including Nike-Hercules and -Zeus and the nuclear-tipped Genie. The Santa Monica firm, according to Donald Douglas, Jr., president, considers liquid rockets "interim" powerplants for missiles. Douglas is also proposing solid engines in its bid for a new Army surface-to-surface missile and is bidding on motor cases for solid propellants—items Donald Douglas, Jr., calls "airframes of the future."

more on next page

AIR FORCE'S decision to procure the ALBM, which will be used on the NAA B-70 and perhaps also on the Boeing B-52 and Convair B-58, is basically aimed at improving the manned bomber's potential.

According to Brig. Gen. Austin W. Betts, USAF expects the ALBM to "keep manned aircraft effectiveness at high levels for an indefinite period as far in the future as one can foresee at this time."

Work for future defense against ballistic missiles

NEW APPROACH to provide defenses against enemy ballistic missiles for the next two decades represents ARPA's major "blue sky" effort to date.

As part of its Project Defender, the agency has created the Glipar program (*G*uide *L*ine *I*dentification *P*rogram for *A*nti-Missile *R*esearch) and chosen the Office of Naval Research to monitor 12 Phase I study contracts totaling $1.5 million.

Basically, ARPA is asking 12 companies to study every possible type of defense (death rays, anti-gravity devices, etc.) without considering its present practicability. Those proposals proved physically impossible even for the remote future will be eliminated. All others showing promise of being useful 20 years from now will be reserved for further research.

AFTER SIX MONTHS of individual study, all 12 Glipar contractors will jointly evaluate all approaches that have not been rejected. ARPA will then decide which, if any, warrant further research.

Firms holding Phase I Glipar contracts include Aeronutronic Systems, Allied Research Associates (of Boston Mass.), U. of Chicago; Convair-San Diego; General Electric Tempo (of Santa Barbara, Calif.), General Mills, Hughes Aircraft, Industrial Research Associates (of Baltimore, Md.), RCA (Burlington, Mass.), Republic Aviation, Technical Operations (Burlington, Mass.), and Thompson Ramo Wooldridge (Los Angeles).

■

LATEST CALL for the abolition of the Advanced Research Projects Agency came from Lt. Gen. Bernard Schriever, head of the Air Research & Development Command. He thinks the DOD agency should be abolished in July and the individual services be assigned ARPA's space and anti-missile projects.

Schriever says ARPA did a good job in filling the vacuum in Pentagon space thinking just after Russia's first Sputnik went up. But he believes the agency is now complicating the space situation because there are no clear-cut channels for making decisions and only partial responsibilities at the operating level. Under Schriever's proposal, USAF would get $367 million of the $459 million ARPA is seeking for fiscal '60.

BEST CURRENT GUESS in Washington is that ARPA will be permitted to go out of existence later this year. If that happens, ARPA's functions will probably be assigned not to the individual services, but to Dr. Herbert F. York and his office of the Director of Defense Research and Engineering.

Bullpup, Hound Dog, Bomarc, Hawk in missile news

LATEST developments on U.S. missiles:

- Navy's Bullpup air-to-surface missile has become operational aboard the USS Lexington. Produced under a $20.4 million contract at Martin-Orlando, Bullpup—which has a USAF counterpart, the White Lance—weighs 540 lb, including a 250-lb non-atomic warhead.
- North American's GAM-77 Hound Dog supersonic air-to-surface missile was successfully test-launched at Eglin AFB, Fla., from a B-52. The Hound Dog uses P&WA's J52 turbojet and inertial guidance to reach its target.
- Douglas MB-1 nuclear-warhead missile, which travels at Mach 4, costs only $7000 a copy without the A-warhead. Addition of the nuclear warhead kicks the price up to $250,000 a copy. The MB-1 is now in use on the McDonnell F-101B, Convair F-106, and Northrop F-89J.
- Booster rocket tests on the 400-mile-range Super Bomarc are being conducted by Boeing at Larson AFB, Wash. About a dozen firings are scheduled for the solid fuel booster, now in experimental production at Thiokol.
- Army's Raytheon Hawk low level surface-to-air missile will be cold-weather-tested at Fort Churchill, Man., during the first three months of '60.

■

LATEST developments on space activities:

- Army will launch two five-stage rockets from NASA's Wallops Island, Va., facility this

more on page 26

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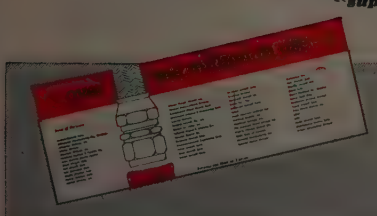

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summer to explore the ionosphere. Each will carry a 15-30-lb payload 1200 miles into space. The 7000-lb rocket will be made up of an Honest John, two Nikes, a Recruit, and a scaled-down Sergeant.

• NASA postponed its planned firings toward Venus (slated for April and June) because of "engineering difficulties in the payload and the boost vehicle system." First of three satellites had been scheduled for launching into an elongated, 30,000-mile-high orbit to test the equipment. The other two "paddle wheel" satellites had been expected to provide data on cosmic radiation while traveling toward Venus.

• Re-entry portion of Lockheed's recoverable Discoverer II satellite was built by GE's Missile & Space Vehicle Department. Capsule, as yet unfound after being reported seen re-entering over Scandinavia, contained a re-entry shield, afterstructure, and experimental package, as well as a re-entry parachute and other recovery aids. The environmental package houses air circulating fans, air scrubbers to eliminate carbon dioxide, oxygen supply, and temperature-regulating devices.

• Douglas got a $24 million NASA contract to develop the Thor-Delta launching vehicle. The craft will be used in '60-'61 and until larger boosters are ready. It will be a three-stager like Thor-Able, using the Thor first stage but a Vanguard second stage with radio-inertial and active guidance between second-stage burnout and ignition of the third stage. Second stage of Thor-Delta will hang on during coasting.

Each Thor-Delta will place 250 lb in orbit or fire 100 lb into deep space

DOUGLAS will provide 12 Thor-Deltas over the next two years. Each will be capable of placing 250 lb in orbit or firing a 100-lb payload on deep space missions.

• Aerojet-General is carrying on a $250,000 feasibility study to develop a solid fuel rocket producing one million pounds of thrust, nearly four times more powerful than any solid fuel rocket used by the West. It considers the engine the forerunner of rockets developing 10-15 million lb thrust.

• Rocketdyne test-fired an early version of its 1,000,000-lb liquid fuel engine to prove out the design of the thrust chamber and injector.

• NASA's four-stage solid-propellant Scout rocket will launch satellites next year with Canadian-designed payloads. Scout launching pads will be built at the Pacific Missile Range and at Ft. Churchill. The polar orbits will provide data on charged regions of the atmosphere in the Arctic.

• General Dynamics' General Atomic Division is running Project Orion studies on the feasibility of a 1000-ton space platform propelled by controlled nuclear explosions within the atmosphere and beyond. One million in ARPA and ARDC funds are being spent on the project in fiscal '59. Follow-on awards will depend on results of this year's studies.

Two space probes, three satellites and 80 sounding rockets to be fired in next two years

NASA'S DR. HOMER J. NEWELL, assistant director of the Space Sciences Division, says we will fire two space probes, three satellites, and 80 sounding rockets over the next two years. The sounding rockets will acquire data up to 100 miles above the earth; the satellites will cover the area over 100 miles. One space probe will study conditions around the moon; the other will try to reach Venus and Mars.

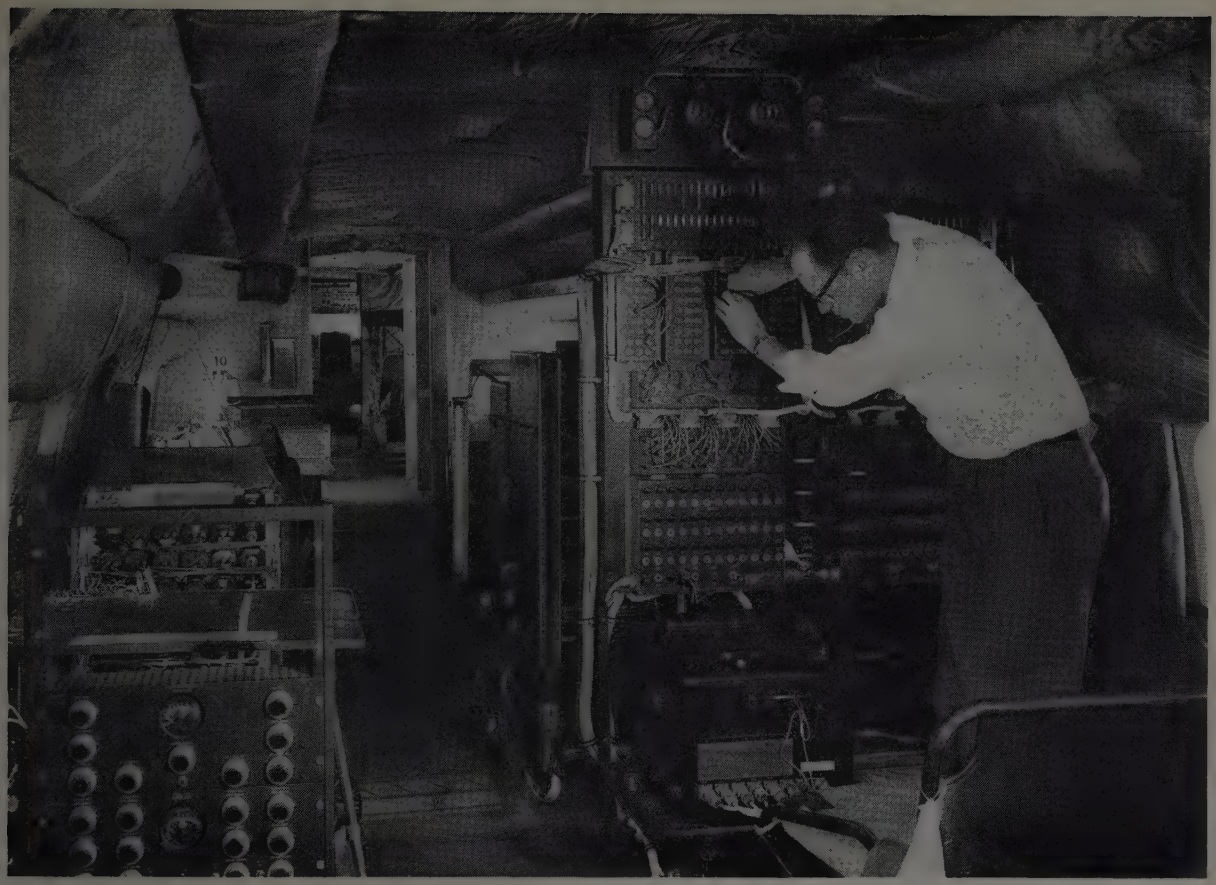
The Mars-Venus probe will be boosted by Vega, for which $42.8 million have been requested and which uses a modified Atlas first stage, a modified Vanguard second stage, and a 6000-lb thrust third stage with storable propellant features now being developed by NASA's Jet Propulsion Lab.

For Centaur, the potential moon rocket $41 million have been requested. It will use a modified Atlas first stage, a P&WA high energy second stage, and Vega's third stage.

•

THE J75 TURBOJET in use on the Republic F-105, Convair F-106, Martin P6M, and other aircraft, may be built under license in France. P&WA and SNECMA company have already signed agreements covering maintenance of civil J75s (JT-4s) on Boeing 707 Intercontinentals. The two firms are also reportedly discussing licensing agreements covering the output of the large engine in France.

If the negotiations go through, the J75 will be used on the second batch of Dassault Mirage III interceptors and on the production model of the larger twin-jet Mirage IV Mach 2 bomber.



This is the cabin interior of Lockheed's test Electra airplane. The engineer adjusts control panel for oscillographic recorder at lower right

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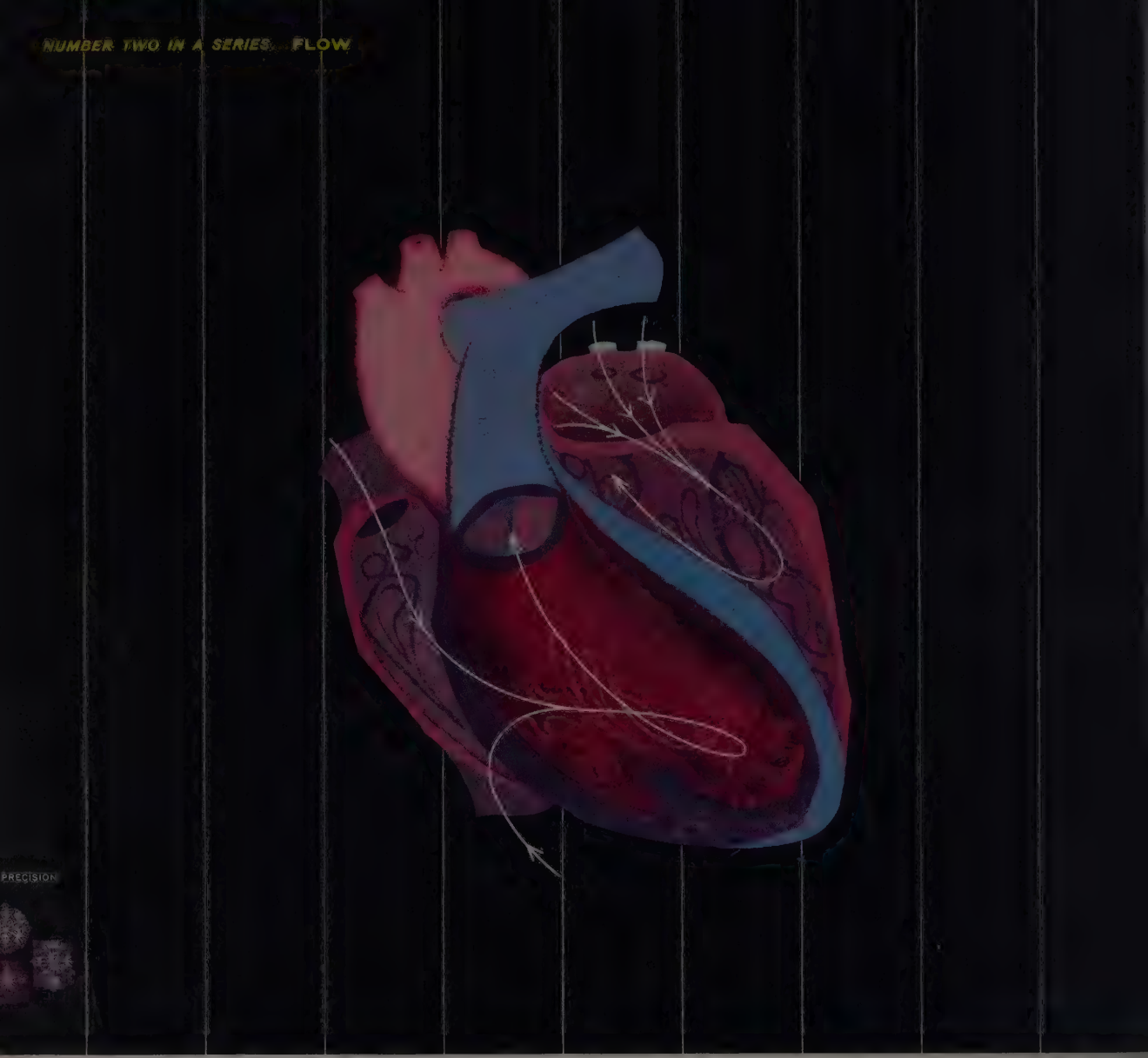

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SELECTION OF TRAJECTORY for space vehicle flight through the two bands of the Van Allen radiation belt can have great effect on the radiation dosage humans must withstand, H. J. Schaefer, of U. S. Naval School of Aviation Medicine, Pensacola, Fla., told Aero Medical Association's annual meeting in Los Angeles. If a radial shot — a straight-line course from the earth to the moon is used — instead of the transfer ellipse of Pioneer, and Lunik — radiation exposure may be cut by as much as one-third, he noted.

The critical intervals the vehicles must spend in the two high intensity radiation belts, Schaefer stated, are about seven minutes for the first and 15 minutes for the second. Having the vehicle occupants assume a fetal position behind shielding seems best for minimum radiation dose for short duration travel through intense radiation fields, he reported.

Biologist's approach to be used in R&D on manned space flight?

BIOLOGISTIC PROBLEMS of supplying man in space require new approaches to applied research, Lt. Col. Albert Taylor, chief of Biomedical Div., Directorate of Life Sciences, ARDC, told the Aero Medical meeting. He proposed consideration of the biologist's technique of setting up a small human community that can be isolated and yet observed, for study of such factors as food supply through such means as hydroponics, waste regeneration, etc.

These factors could first be studied in a large environment, such as a farm. Once the major problems of maintaining this group had been solved, the next step would be a study of area miniaturization to make the sytem feasible for space travel.

TAYLOR CONTRASTED this method with the engineering approach of estimating biological needs and then building equipment to try and meet them. Because of the complexity of the problem, elements of both approaches will probably be needed for manned space travel.

•

HUMAN FACTORS instrumentation for X-15 will include some 600 temperature and 140 pressure pickups, with a total weight of over 1300 lb, Lt. Col. Burt Rowen, USAF Medical Corps, told the meeting. This compares with only 350 lb of instrumentation, including 15 temperature probes, on the X-2.

X-15 pilot's suit and helmet separately pressurized

FULL PRESSURE SUITS to be worn by X-15 pilots, Rowen stated, have 24 electric contact points for connections between physiological sensors or transducers and telemetry transmitters. Eventually, data to be monitored to the ground will include helmet pressure vs suit pressure differential, pilot's body surface temperature and electrocardiographic data. Information will be received at NASA High Speed Flight Station at Edwards AFB, Calif., where it will be monitored by flight surgeon familiar with X-15 program.

X-15 pilot's pressure suit will be pressurized and cooled by nitrogen. The pilot's helmet is pressurized with 100 per cent oxygen separated from the suit by a rubber seal at neck. One-fourteenth psi of oxygen provides extra pressure to keep nitrogen from seeping into the helmet.

■

ANIMAL RESEARCH and its application to human operation of new vehicles has changed with the advent of space age, Brig. Gen. Don Flickinger, Assistant for Bioastronautics, ARDC, told the meeting. In past, data on human and animal subjects from dynamic ground-based tests (centrifuge, rocket sleds, etc.) often could be directly correlated. Now researchers are forced to extrapolate from both human and animal data for experimental equipment design, since it's not possible to duplicate the full spectrum of space flight stresses on the ground.

Inert-gas-shielded tungsten arc welding best for thin gages

CLOSE CONTROL of process variables is key to successful welding of thin foils, John Campbell, Air Reduction Research Lab, told recent American Welding Society meeting in Chicago. Tests run on gages from 0.002 to 0.005 in. indicated inert-gas-shielded tungsten arc welding was best, he stated.

Accurate edge preparation and very careful study of the arc's volt-ampere characteristics are

more on next page

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essential. Campbell pointed out that the contour of the welded joint is affected by the arc and surface forces on the molten weld pool. The metal is slightly displaced to one side by these forces, giving a thinner section for plain butt joints. Proper design of hold-down and back-up strips is needed to limit this effect Campbell said.

Delta will be similar to Thor-Able vehicle

DELTA LAUNCH VEHICLE contract was awarded to Douglas. This craft will be used until large boosters, now in development, are available.

Modified Thor will be used as the first stage of the three-stage configuration, which will be similar to the Thor-Ables of last year. The second stage will be powered by a redesigned Aerojet-General liquid propellant engine and will house an improved inertial guidance system. The first stage will have a Rocketdyne liquid propellant engine and the third stage a solid propellant unit made by Allegany Ballistics Lab.

DELTA WILL BE 90 ft high, weigh 100,000 lb plus, develop over 150,000 lb thrust, and be able to put a 250-lb payload in 300-mile earth orbit or send a 100 lb payload on a deep space mission.

Douglas will build 12 Deltas over next two years.

Well-oriented crystals improve strength of ceramics at high temperature

STRENGTH of ceramic materials at high temperatures can be improved by properly oriented crystals, so that plastic deformation relieves stress concentrations, Bureau of Standards research indicates. Current studies are on aluminum oxide single crystals (sapphire and ruby) at temperatures between 600 and 1000 deg C.

Strength of polycrystalline aluminum oxide, NBS points out, is known to decrease with increasing temperature above 800 deg C. In one set of measurements on single-crystal aluminum favorably oriented for plastic deformation, crystal strength increased with temperature in this range. Further studies made with the crystals so oriented (45 deg) gave similar results, NBS states.

•

HIGH FREQUENCY induction heaters used with new automatic brazing and soldering facility developed by Raytheon have cut brazing and soldering time for missile components by 90 per cent. The system is used in producing missile gyroscopes and accelerometers.

New setup is designed to handle silver brazing, lead-tin alloy soldering, shrink fitting, hardening, tempering, and local stress removal — all in controlled atmosphere. Brazing can be done in hydrogen atmosphere, with nitrogen purge after each operation. Time required for this operation has been cut from three minutes to 18 sec.

THE HEATERS were designed by General Electric. They make it possible to hold production tolerances and closely control temperatures from 90 to 3000 deg F, GE states.

"Heat-sink" cladding may qualify refractories for high temperatures

HEAT-EXTRACTIVE brazed bi-metals promise to make refractory metals (tantalum, molybdenum, columbium, tungsten) suitable for extreme temperatures, a new WADC program indicates. This "heat-sink" clad method, R. C. Bertossa, of Pyromet and Steven Rau, Stanford Research Institute, told the recent American Welding Society meeting, involves brazing of relatively thick, high-thermal-conductivity copper to a thinner refractory sheet. (Work so far has been done with tantalum.)

Vacuum and vacuum-inert-gas-atmospheres are used to gain superior continuous brazed joints, since oxidation or excessive voids at bond interface will greatly reduce effectiveness of the copper layer in removing heat from the refractory metal. High temperature exposure test in rapidly flowing oxidizing gases at temperatures over 3600 deg F showed such assemblies able to take as much as 14 minutes exposure before the outer tantalum shell failed, Bertossa and Rau said.

•

NEGLECT of basic welding principles causes many problems in fatigue failures of welded joints for aircraft and missiles, J. Koziarski, of Martin-Denver, told the American Welding So-

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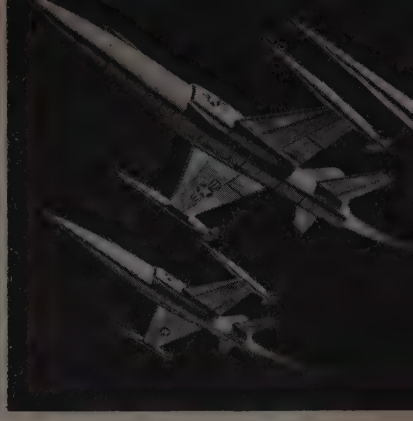
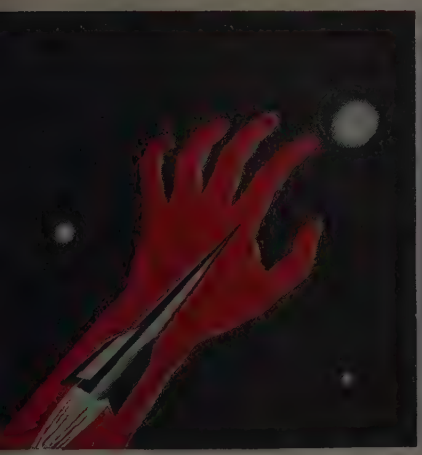
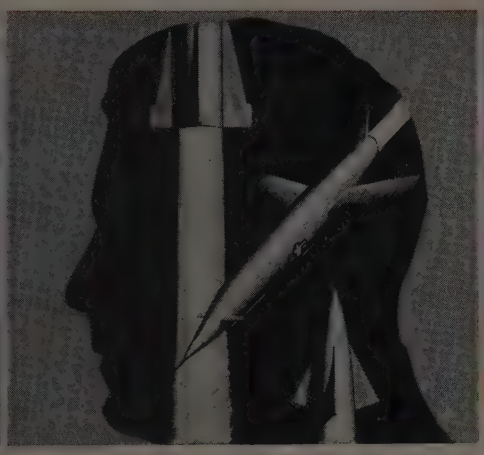
Idea sessions on going places in the sky often put

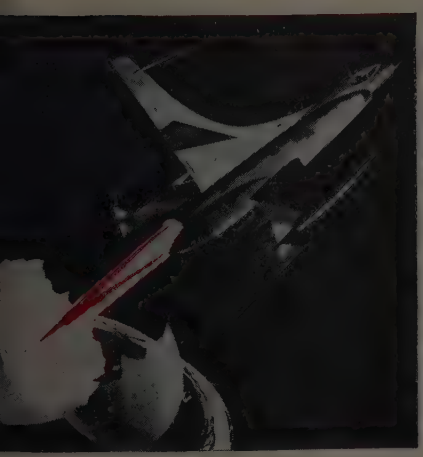


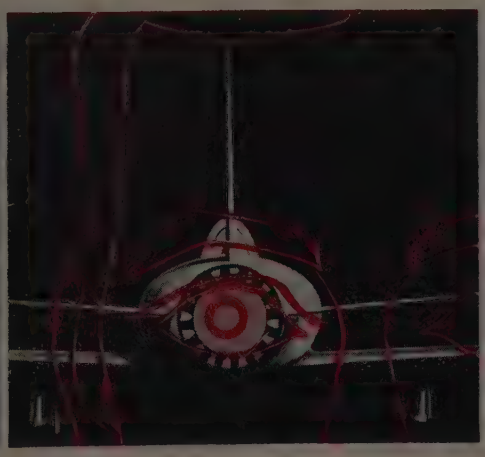
the future as near as the next thought. When talk of

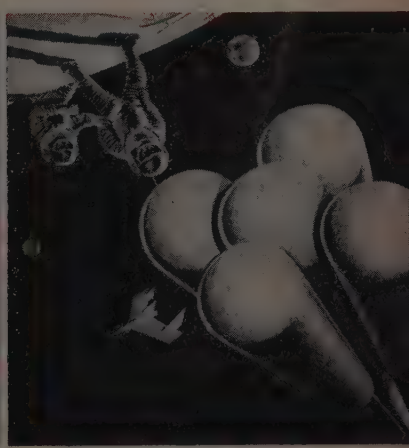




ability turns to availability, think of Ex-Cell-O for the







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ciety meeting. "Many designers think in riveted terms when designing welded structures," he stated. "The lack of proper basic education in the technology of welding and in welding design . . . are responsible for this."

Koziarski pointed out that welded joints should preferably be designed in tension rather than shear. He criticized ANC-5 requirements that shear be given preference to tension in welded joints as "one of the residues left from riveted design philosophy." International data, he noted, proves conclusively that, particularly with welded joints subject to fatigue, welds working in shear are greatly inferior to those working in tension or compression.

New design possibilities foreseen in ultrasonic welding

"THE MISUSE of 'stop rivets' in aircraft spot-welded structures is another fallacy," Koziarski stated. "The marriage of a rivet with a spot weld is a very unhappy one; they do not and cannot work in unison. In a mixed joint, since a rivet is more ductile than a spot weld, the spot weld picks up more load and usually fails first." One answer, Koziarski believes, would be the use of ultrasonic welding.

Ultrasonic welding also will open many new design possibilities, Koziarski stated. It will make it possible to weld very thin sections to themselves, to weld dissimilar metals, as well as to weld refractory metals, such as beryllium, he reported.

•

VEGA LAUNCHING VEHICLE is being developed by Convair-Astronautics under a $33.5 million contract that calls for eight vehicles to be delivered by the end of '61. Vega will consist of a modified Atlas first stage, a Vanguard booster second stage, and a new JPL third stage that uses storable fuel. Fully loaded, it will weigh about 295,000 lb and stand 140-150 ft.

Better range and altitude for new Bloodhound

ADVANCED BLOODHOUND surface-to-air missile will succeed the Bristol-Ferranti Bloodhound system now in service with RAF. The new version will have "substantially increased operating range and altitude."

HIGH ENERGY oxidizers for advanced solid propellants are being studied by Allied Chemical's General Chemical Div. under an Army contract. Project involves chemical research leading to synthesis, characterization, and evaluation of new oxidizers suitable for compounding in solid propellants.

Third Argus radiation shield lasted several weeks

NEW ARGUS DATA reveals the shield produced by the third blast persisted for at least several weeks. It declined gradually in intensity but stayed fairly constant in position and thickness. The first two blasts collapsed, both on the same day, about a week after they were fired. It is believed the cause was an eruption of the sun that affected the earth's magnetic field.

•

NEW SOLID composite propellant developed by Chromalloy's Propellex Chemical Div. is said to have improved physical properties. Chief advantage is that it has a lower temperature coefficient, which results in less performance variation with temperature change.

Chromalloy also claims the new propellant will withstand prolonged storage at high temperatures better than previous propellants. The new propellant is being made in pilot plant quantities.

Main sheet of B-70 and F-108 will be PH15-7Mo

PH15-7Mo STAINLESS steel, developed by Armco Steel, was specified as the main sheet construction material for the B-70 and F-108. However, says Armco, PH15-7Mo is not the ultimate for a precipitation-hardening stainless steel. The company has steels in the lab with even better properties.

•

25,000,000-V BETATRON being built by Allis-Chalmers will be delivered to Allegany Ballistics Lab this summer for X-ray testing of solid propellant fuel blocks for the Polaris IRBM. Betatron will be suspended from test cell ceiling by twin telescoping tubes and be able to rotate on its vertical and horizontal axes.

ION PROPULSION UNIT may be fully tested and proved out by '61. Two GE engineers at last month's ARS meeting in Cambridge, Mass.,

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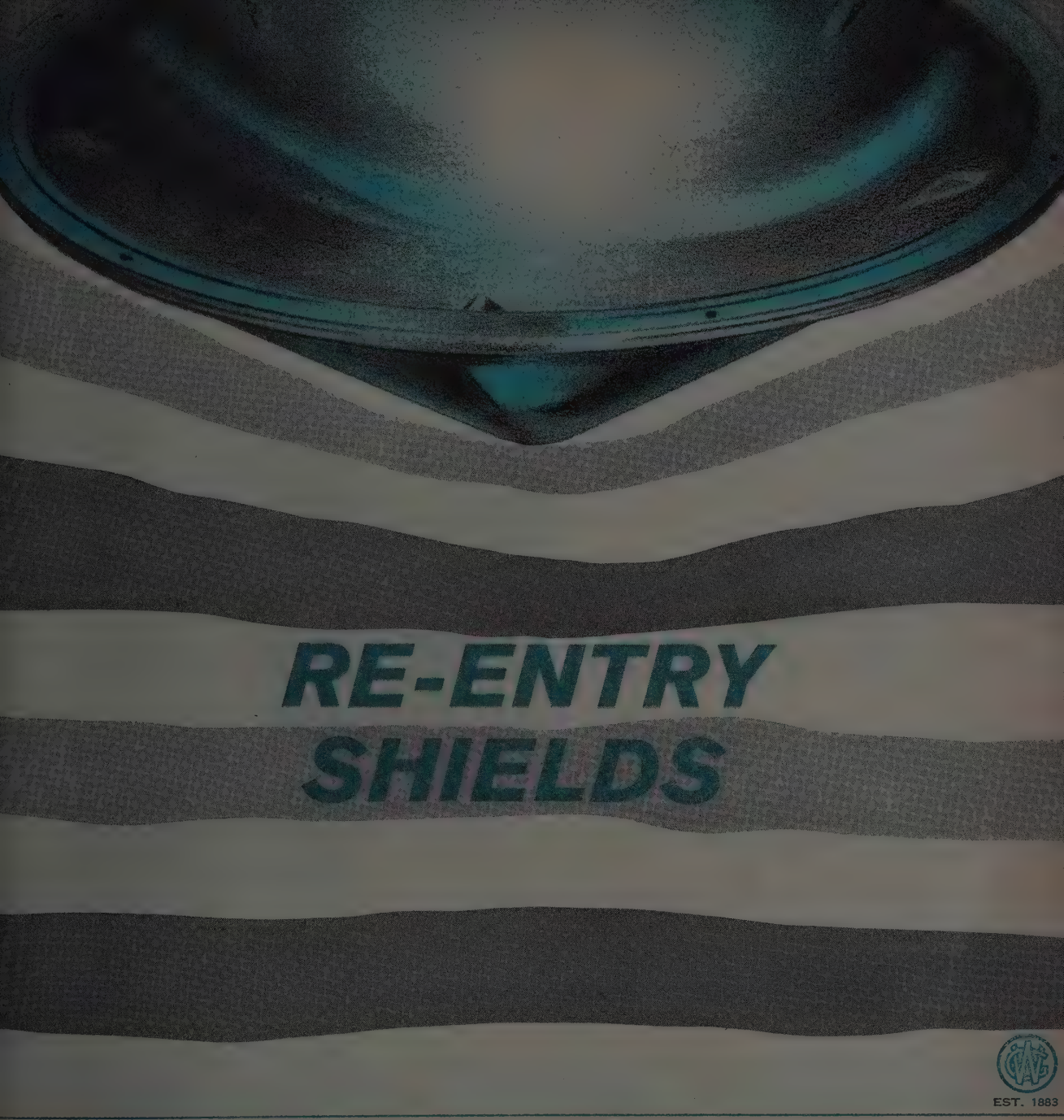

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said a small ion engine they are now testing in the lab could be ready for testing in space by '61 or very early '62 at the latest.

More than enough thrust is generated, they say, for good attitude control. Advanced designs for altering a satellite's orbital path could be ready for flight-testing in '64 or '65, they estimate.

Missiles slated for "interceptor" submarines?

MINIATURE ATOMIC SUBS are being considered to back up the Fleet Ballistic Missile subs. The "interceptor" subs would have a displacement of about 400 tons and carry a crew of 10-15. Reportedly each would be armed with underwater-to-underwater and underwater-to-surface missiles.

AERONUTRONIC'S anti-tank missile can be launched from a moving tank against stationary or moving targets. Single crewman optically sights the missile for launching, after which the missile homes in on the target. Fire control for the anti-tank missile system is being developed by Raytheon.

Lycoming constant-speed drive takes extreme temperatures in test

CONSTANT-SPEED DRIVE developed by Lycoming has passed Navy qualification tests. The 20-kva unit was operated at ambients of up to 365 deg F during the tests; input speeds varied from 2300 to 8500 rpm. Transmission was also kept in an ambient of —67 deg F for 74 hours and then started successfully.

The unit weighs 55 lb and has a steady-state frequency control output of ±¼ per cent.

HYDROCKET water jet engine has been developed by Aerojet-General's ASW division. According to Calvin A. Gongwer, division manager, theoretically there is no limit to the speed that now can be reached by vessels of any size "provided they have the proper hull design."

A prototype model of the Hydrocket being tested on small craft has a hollow-metal-disk impeller about a foot in diameter. The impeller has a water inlet, or eye, at the center. The water is ducted through internal vanes to a series of slanting exhaust nozzles in the periphery.

THE IMPELLER, geared to the engine's drive shaft, pumps out a stream of water admitted through a scoop in the bottom of the hull. The water is forced out the nozzles as a whirling spray that drives the boat forward. A rudder or vanes deflecting the spray can be used for directional control.

A speed increase of at least 75 per cent is expected at over 40 knots. Cavitation and water drag are also cut, since the Hydrocket's impeller is clear of the water when underway.

Hydrocket mods possible for other ships

THE PRESENT HYDROCKET is designed for surface craft with comparatively flat bottoms that skim across the water's surface rather than knife through it. However, Aerojet says the engine could be modified for ocean vessels similar in design to hydrofoil boats or for underwater cargo ships.

PROJECT ORION has been officially related to the concept of propelling a 1000-ton space platform by a series of controlled nuclear explosions within the atmosphere and beyond. The project was discussed by Roy W. Johnson, director of ARPA.

Project Orion is but one of a number of investigations involving new means of propulsion for space applications. The study is being carried out by General Dynamics' General Atomic Div. under a $1 million contract for fiscal year '59. Whether or not the study will be continued beyond that date depends upon the result of the initial phase.

GE's JT-3D turbofan engine to be used on DC-8

P&WA PROVIDED DETAILS on two turbojets it has under development. The J58, originally the backup for the GE J93 to be used on the B-70 and F-108, is a single-spool engine in the 30,000-lb thrust class. Preliminary tests have been successful at P&WA's Florida R&D facility.

The turbofan version of the J57 (JT-3D) provides a third more thrust at takeoff, up to 12 per cent less fuel consumption, and up to 10 per cent less engine noise. First deliveries are scheduled for mid-'60.

The JT-3D will be used on the swingtail cargo version of the DC-8.

Again...

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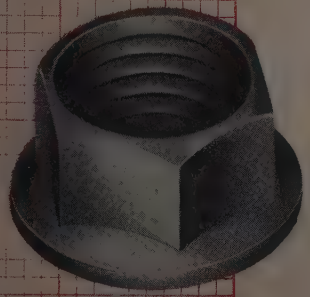

Type LH3324 (160,000 psi)

THIS NEW DESIGN is ESNA's recommendation for applications where space and weight reduction are primary needs. Meets MIL-N-25027; reduced wrenching dimensions permit more efficient centerline bolt design; wrench heights carefully engineered to assure satisfactory assembly line performance. Materials: carbon steel, AMS6304 alloy steel and A286 stainless steel.

wt in lbs per 1000	Screw Size # 4	# 6	# 8	# 10	¼"	5/16"	3/8"	tensile rating
LH3324	.2	.6	1.3	1.4	2.9	5.4	7.3	160,000 psi
NAS679	.9	1.7	2.4	2.6	4.6	6.4	8.6	140,000 psi
AN365	1.4	2.6	4.2	5.0	9.0	12.0	18.0	140,000 psi

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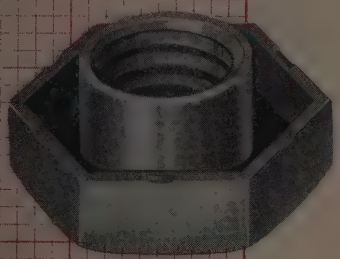

Type LHTE-TM (NAS 679 140,000 psi)

This complete line of low-height, lightweight NAS 679 hex nuts has been designed and produced to ESNA's exacting quality standards. Qualified to MIL-N-25027. External-internal wrenching surfaces for easy installation in limited access areas. Sizes 4-40 through 7/16-20. Alloy steel for temperatures to 550°F; A286 stainless steel for temperatures to 900°F and nonmagnetic applications.

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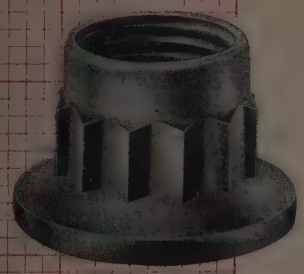

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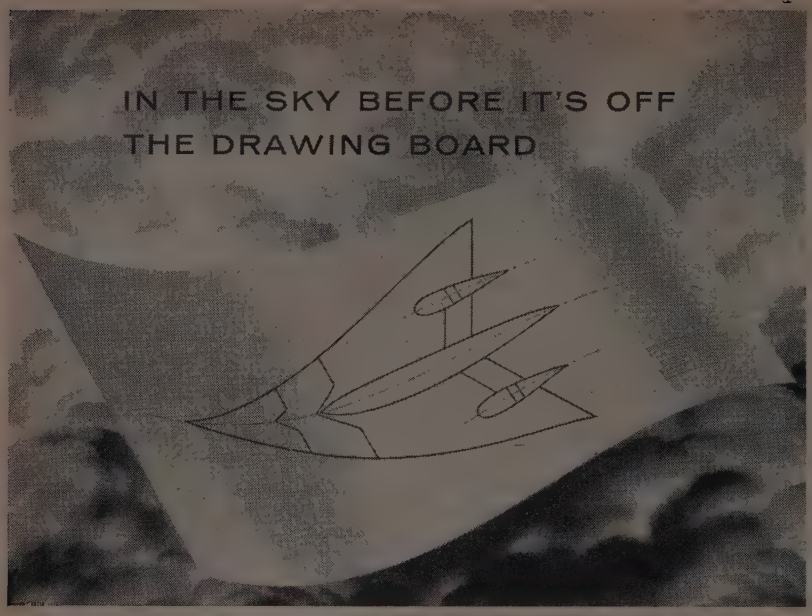

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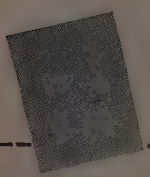

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calendar

June 4-5—Third National Conf., Institute of Radio Engineers' Professional Group on Production Techniques, Villa Hotel, San Mateo, Calif.

June 5-6—Annual Meeting of the Army Aviation Assn. of America, Shoreham Hotel, Washington, D. C.

June 5-6—10th Annual Maintenance & Operations Meeting, Reading Aviation Service, Inc., Municipal Airport, Reading, Pa.

June 7-9—Structures Fatigue, "Full Scale Testing," sponsored by Advisory Group for Aeronautical Research and Development, Amsterdam.

June 8-9—Industry Missile and Space Conf., Sheraton-Cadillac Hotel, Detroit, Mich., Aero Club of Michigan.

June 8-11 — Semiannual Meeting and Astronautical Exhibition, American Rocket Society, El Cortez Hotel, San Diego, Calif.

June 8-12—"Chemistry of Propellants," Combustion and Propulsion Panel, Paris.

June 12-21—23rd French International Air Show, Le Bourget, Paris, France.

June 14-18—Semiannual Meeting, American Society of Mechanical Engineers, Chase Park Plaza Hotel, St. Louis, Mo.

June 14-19—Summer Meeting, Society of Automotive Engineers, Chalfonte-Haddon Hall, Atlantic City, New Jersey.

June 16-19 — National Summer Meeting, Institute of Aeronautical Sciences, Ambassador Hotel, Los Angeles, Calif.

June 18-20—ASME's Applied Mechanics Division Conf., Virginia Polytechnical Institute, Blacksburg, Va.

June 21-26 — Summer-Pacific General Meeting and Air Transportation Conf., American Institute of Electrical Engineers, Olympia Hotel, Seattle, Wash.

June 23-25—33rd Meeting, Aviation Distributors and Manufacturers Assn., St. Francis Hotel, San Francisco, Calif.

June 24-26 — Air Transportation Conf., AIEE, "Electricity in Space," Olympic Hotel, Seattle, Wash.

June 24-26—Second Nuclear Instrumentation Symposium, Instrument Society of America, Idaho Falls, Idaho.

June 29-July 1—Third National Convention on Military Electronics, Sheraton-Park Hotel, Washington, D. C., IRE's Professional Group on Military Electronics.

June 29-July 3—Summer Seminar on Plastics—Its Mechanical Properties, Design and Applications, Pennsylvania State University, University Park, Pa.

July 13-15 — Tenth Anniversary Meeting, Airlines Electronic Engineering Committee, Ambassador Hotel, Los Angeles, Calif.

July 30-31—Sixth Annual Symposium on Computers and Data Processing, Denver Research Institute, Stanley Hotel, Estes Park, Colo.

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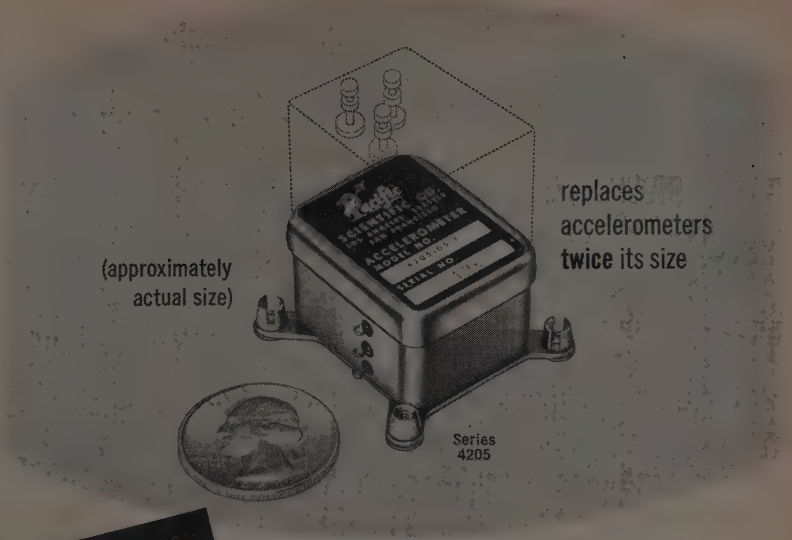

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European aerospace industry moving toward integration

● Britain looking for closer ties with Continent to meet competition from common market countries

by Denis Desoutter, Foreign Corresponding Editor

TECHNICAL MANAGEMENT in the European aerospace industries is facing big changes, just as is its counterpart in the U. S. This is true not only in engineering methods but also in basic organization.

The influences behind this change are not, however, as in the U. S., mainly technological. Economics plays a larger role. In England, economic winds influencing the course of its industry are caused by the "low pressure areas" of British government policy and the growth of the European common market. British policy has been to emphasize missiles at the expense of R&D on supersonic and hypersonic aircraft. The common market countries on the Continent offer a potential threat to the overall leadership of the British industry.

Over the period from 1953 to 1956 (for which we have good statistics), British aviation exports to the Continent averaged $40 million a year. The nearest European competitor was Italy, with less than 10 per cent as much export business. Holland was next with slightly below nine per cent of the British figure.

But even in that period, the sales of other European aircraft manufacturers were beginning to gain on Britain. Since then the change has been even more marked, brought on by such products as the Fokker Friendship, the Sud Aviation Caravelle, and the Fiat G-91.

The aviation products Britain has been able to sell have been mainly complete aircraft and engines. Most of the aircraft have been military types that emerged at and after the end of World War II. There also has been a good sale of Viscounts. Gas turbine engines continue to sell well, and in some cases there have been license agreements. But the holders of such licenses haven't been able to go into production with the licenser's latest models.

This lag has created a certain dislike of such licenses in the minds of some Continental manufacturers. It has also led to some remarkable technical achievements on the Continent.

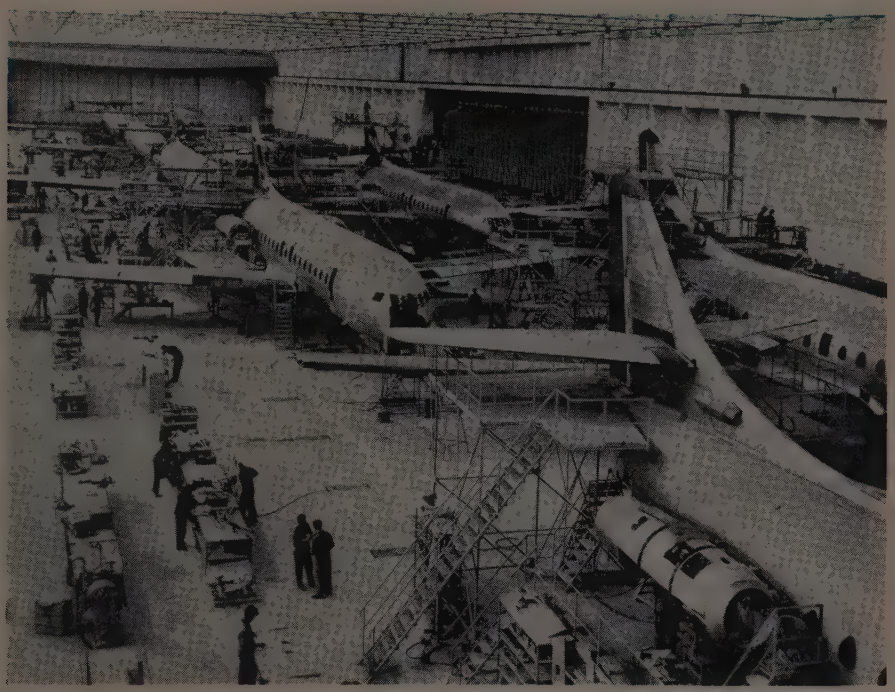
Take, for example, the extent to which Hispano-Suiza was able to develop the old centrifugal flow Rolls-Royce Tay by the use of air-cooled turbine blades (when they were still a novelty). Or Dassault, which developed a larger version of the 1630-lb thrust Armstrong Siddeley Viper, the Farandole, which gives twice as much thrust.

Licensing is not all one way

The licensing hasn't all been one way. Blackburn adopted the Turbomeca range of small turbines. Bristol has shown its willingness to make use of a good French idea in thrust reversers when it took a license from SNECMA (though this project didn't bear fruit in the end).

On both sides of the channel, license holders have had to cope with the problems of the different dimensional systems. Yet, by and large, the British firms have had the best of it. In particular, the French haven't been happy about the British domination of European markets. Full of advanced technical ideas themselves, they have wanted an outlet for their products both through NATO and the airlines.

A few years ago, they were anxious to reach an



CARAVELLE production is widely spread out over a large part of France's aerospace industry.

agreement with the British industry that would give them a greater share of the business. But no British manufacturer was willing to throw away any of the cards in his hand.

Disappointed, the French, led by Georges Héreil, Sud Aviation's president, turned to West Germany. Nord sold its very successful Noratlas transport to the Luftwaffe. About 140 of the planes have been ordered —25 have been delivered complete from France; others are to be built under license by Nordflug.

British output to be cut by 40%

Franco-German collaboration was getting into full swing just when the British industry was starting to feel the effects of the new defense policy. This policy will cut the industry's output to about 60 per cent of what it was 2-3 years ago. Faced with these difficulties, the Society of British Aircraft Constructors has adjusted its attitude toward the French and other European aircraft industries—1959 certainly will see a new approach in the effort to make friends.

Caravelle production now must account for about 25 per cent of all French aircraft industry activity, with some 280 firms in the program. This concentration of a very large part of French capacity on one project is mirrored in Britain, where the government is spending its money according to a new idea—to reduce the airframe makers to four and the engine firms to two. At the same time, new projects are to be speeded up by bringing in more than one firm on each.

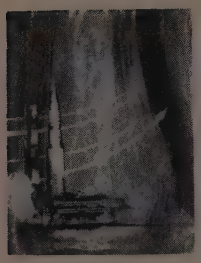
In general, there is a marked increase in internationalism. Buying of accessories no longer is on a national basis—what matters is the best value. Equipment is bought anywhere in Europe or in the U. S., but not yet in the USSR.

The aim of the common market countries is to break down research costs among themselves and work toward a common procurement policy. Little thought is likely to be given to building long range airliners on the Continent.

But everywhere in Europe aircraft makers have other irons in the fire—from the yachts made by Fairey to the motor scooters made by Piaggio. Saab makes cars, Sud Aviation makes refrigerators. Rolls-Royce is in the car business, and so is Hispano-Suiza. Blackburn is in construction.

Where the field is the world market, and where the main competitor is the U. S., it is possible for European makers to sell top quality at a lower price, thanks to Europe's lower living standards and wages. But where it is a matter of a European aircraft maker going into the non-aeronautical field, then technical management has to keep a tight grip on costs and make sure too much quality isn't built into the goods.

Some trends that seem fairly clear: There will be bigger production units, with groupings of firms and groupings of countries. Britain will remain dominant, but the Franco-German team will increase its strength. Italy, Holland, and Sweden will be the other major manufacturers. All will look for technical tie-ups with U. S. firms, either to provide outlets for their products or to buy know-how that it would take them too long to get by their own efforts.—End

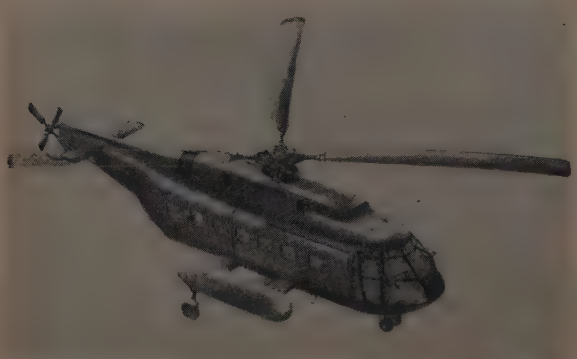


STOLs and VTOLs

highlight European progress

Trend to short and medium ranges for missiles, military and commercial aircraft

by James H. Stevens, Technical Correspondent



FAIREY ROTODYNE (top) with Napier Eland N-El-3 flies in autorotation at 160 knots. Bottom: Sud-Aviation's three-engine SE-3200 copter, soon to come off the line.

RADICALLY NEW projects in Europe are few. With Britain's Defense Minister, Duncan Sandys, convinced by his scientific advisors that manned military aircraft are obsolete and with the other NATO forces limited by policy to fighter bombers, the scope of activity is narrowed.

True, the practicability of a supersonic airliner was considered for two years. A confidential report was made by a Royal Aircraft Establishment committee to the British Supply Ministry in February. The final decision rests with the ministry, since public funds would be needed to back such a venture.

Some research money has been given to the Rolls-Royce-Griffith VTOL project and the Swallow project of Dr. Barnes Wallis at Vickers (see *AvAge, "Supersonic Transports Take Delta Shape," Aug. 1958, p. 42*).

Laminar flow applied on HP-113

Another British line of research is Dr. G. V. Lachmann's laminar-flow theories as applied to the Handley Page 113. This is an executive jet with two 5250-lb thrust Bristol Orpheus engines. Specs call for 12 passengers and two crew, capacity payload range is 5300 miles at 530 mph and 43,-50,000 ft, and max range (with internal fuel) is 6100 miles. Wing span is 71 ft 3 in.; equipped weight, 20,450 lb; gross, 36,500 lb. Landing from 50-ft height at 25,000 lb would be 2480 ft.

Handley Page claims 80 per cent drag is eliminated by removing the turbulent boundary layer on wing and tail—at a cost of only four per cent more weight. The engines are mounted in the rear fuselage and have

SWEDEN's Saab A-32 Lansen all-weather ground attack fighter typifies European preoccupation with tactical defense. It is shown in Saab's underground plant.

individual dorsal intakes. They drive two four-stage axial blowers sucking through ducts in the wing surfaces. The leading edges have porous sintered steel surfaces. The main torsion box skins have 0.005-in. slits and are bonded to stressed structures.

The removed boundary layer air is accelerated through ventral outlets. With a retractable dorsal intake, pumps can be used for takeoff thrust boost. The unlaminarized control surfaces are of very narrow chord and are blown at low speeds by bleed from suction pump delivery.

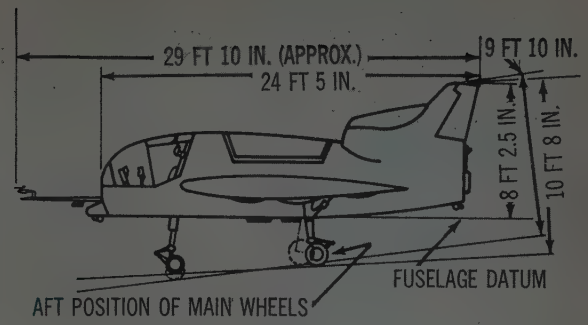
Olympus will use Solar afterburner

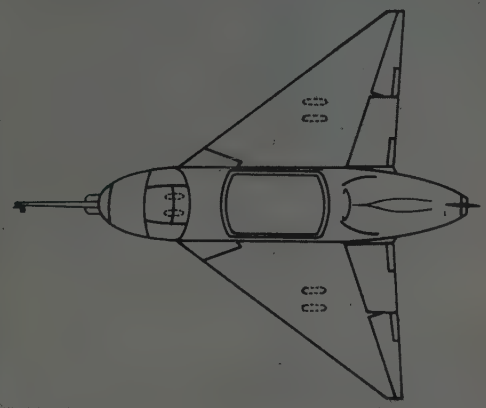
Work by Vickers and English Electric on the TSR-2 RAF tactical supersonic photographic aircraft is still in an early stage. Short strip performance is promised. It could be achieved easily by deflecting jets from power units required for low level Mach 1.7. The TSR-2's powerplant is the Bristol-Siddeley Olympus—already at 24,000 lb static thrust—with a Solar afterburner.

Within NATO, there are two missile-producing countries: Britain and France. The British have standardized a series of weapons designed around results obtained from numerous research vehicle programs. France started with embryonic missiles and worked them up. Each country has two production air-to-air missiles. Britain has three production surface-to-air types and so does France, but the French ones apparently are already obsolete.

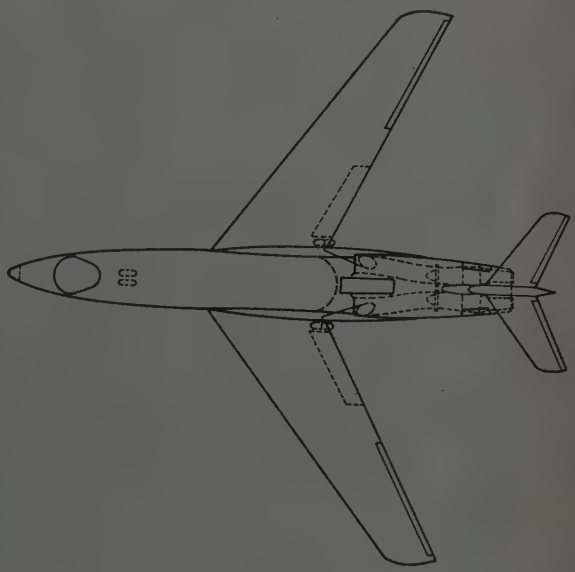
Britain has no "bombardment" missile; France has

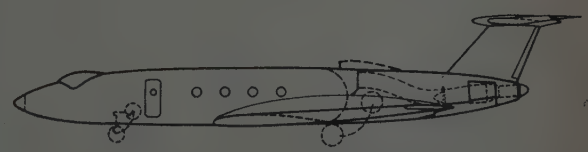
more on next page

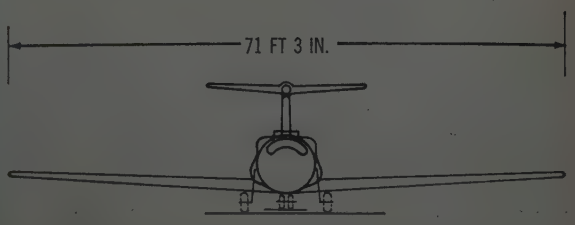




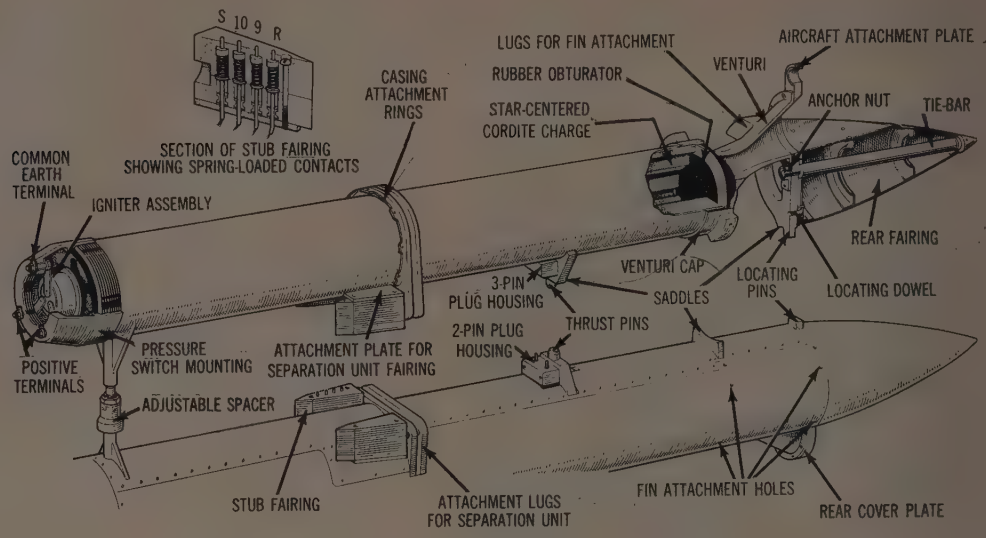
SHORT SC-1 is Britain's first fixed wing VTOL.







HANDLEY PAGE 113 executive jet has boundary layer control. Retractable dorsal scoop is intake for air pump used to boost thrust for takeoff and climb.



FAIREY Fireflash boost rockets and attachment fittings. This air-to-air missile is in service with RAF.

a subsonic one. A large strategic guided bomb is being developed in Britain, while France has a small tactical weapon of this type in service. France also has "infantry" and "cavalry" anti-tank missiles in large scale use. Britain has ordered one design and dropped two private ventures in this field.

There are three British surface-to-air missiles because of the three services' different needs. The RAF required long range area defense (to replace its fighters) and chose the ramjet Bristol-Ferranti Bloodhound. This design will be backed by some of the Army's English Electric Thunderbirds for tactical deployment. The Navy picked the compactly packaged Armstrong Whitworth Seaslug. Each of the three missiles has SAH guidance and is boosted to Mach 2 by four concentric solid propellant rockets.

The Fairey Fireflash, Britain's first air-to-air missile, was dropped because of a policy decision against beam riders and is used for training only. The infrared passive homing de Havilland Firestreak, a heavy weapon, is slated to become operational this year. Its fully developed version is expected to be the real answer.

France's Nord 5103 (AA-20) has radio command guidance by jet deflection. It has 2½-mile range at Mach 1.7. The guidance system "mates" with the systems of Nord's subsonic wire-guided missiles. A heavier model (380 lb against 295 lb) is to be the standard NATO ASM for the Fiat G-91.

Matra R-510 standard for France

The Matra R-510 is a 375-lb canard rocket vehicle with a 66-lb charge and photo-cell active homing. It is standard for French air force interceptors.

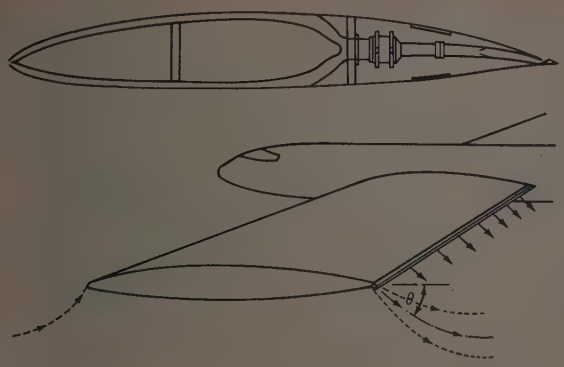
Avro's stand-off missile, to be carried under the bellies of the Vulcan 2 and Victor 2, is an interceptor-size supersonic weapon with a small delta wing, a canard stabilizer, and a triangular tail fin (whose lower half folds for ground clearance at takeoff). The engine is rumored to be the de Havilland Double Spectre rocket, giving a 400-mile range at Mach 2 and 60,000 ft. The warhead will be nuclear. The guidance probably is active and uses radar map painting—possibly coupled with IR homing for industrial targets.

SS-10 95% reliable and accurate

Nord's development of German World War II wire-controlled weapon has been highly successful and continues. Full environmental development and rigorous testing of the whole weapon system, after initial failures under field tests in the U.S., have resulted in 95 per cent plus reliability and accuracy of the SS-10. Training in firing and aiming this weapon is quick, even for ordinary troops. Its firing weight of 33 lb makes the SS-10 easy to handle. Speed, however, is only 186 mph, and range only one mile.

For vehicle and aircraft use, the 69-lb SS-11—435 mph and 2.2 miles—is preferable. This weapon can be used from the Fouga Magister for training jet pilots in ground attack with the AA-20 used on the Dassault Mystère fighters. Thousands of SS-10s and -11s are in French service. In addition, the SS-10 is used by Israel,

NEW SAAB-35A Draken delta fighter has lengthened aft fuselage and retractable dual tail wheel.



JET FLAP principle, patented by Britain's Power Jets (Research & Development), is most promising European contribution to STOL design.

SARO'S single-stage Black Knight rocket research vehicle stands about 35 ft high.

Italy, Sweden, and West Germany. Signal generators and all control equipment, as well as synthetic trainers, are common to both missiles.

Entac, a small very simple anti-tank wire missile designed by DEFA (Direction des Etudes & Fabrications d'Armament) is in an advanced state of development. It will be mass produced by Nord.

By contrast, Fairey's anti-tank missile is large—probably about the size of the Dart, which has been ordered into development for the British Army.

Work on a subsonic SAM, the SX-A5, by Short Brothers & Harland has been confirmed by a Navy production contract (for the Seacat). The Army has ordered development of another version (the Tigercat). Short is also responsible for development and series production of a Royal Aircraft Establishment (RAE) research rocket (see *S/A, "British Test Missile Designed for Easy Parts Access," Feb. '59, p. 66*).

Swedish missiles put in service

Outside NATO, Sweden has placed in service several subsonic missiles developed by Robotbyran. The Robot 315 surface-to-surface missile is used by the Navy. In addition, Sweden has bought the Bristol-Ferranti Bloodhound, the Nord SS-10, and the U.S. Sidewinder.

Switzerland has equipped its forces with the Contraves-Oerlikon beam-riding Type 56 SAM, a Mach 2.4 weapon with 10-66,000-ft altitude coverage. Twelve rounds a minute can be fired from a battery of six double-launchers. The missile's main engine, burning nitric acid and kerosene, gives relatively low acceleration. The Type 56 also is being produced by Contraves Italiana (as the MTG-56) and is an Italian standard training weapon.

Spectre and Scorpion curtailed

Contraves-Oerlikon has also developed a simple, wire-guided anti-tank missile, the Cobra IV, using a solid propellant sustainer. Firing weight is about 24 lb, speed about 180 mph, and range about 4500 ft.

The most significant development in British rocketry is the adoption of high test hydrogen peroxide (HTP) as standard. It was primarily a result of the program for manned aircraft rockets that led to the DH Spectre and Napier Scorpion.

This program has been curtailed by restriction, if not complete abandonment, of fighters by RAF and RN. The

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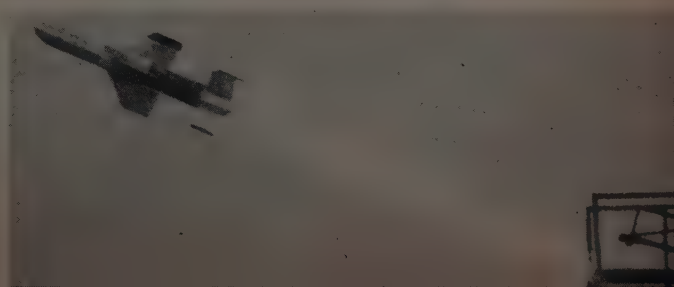
NORD'S latest wire-guided anti-tank missile is SS-11, to be launched from jeeps and 'copters.

SHORT Seacat prototype. This short range SAM will replace 40-mm batteries on Royal Navy ships.



"HORIZONTALIZED" RB-145 version (left) of Rolls-Royce RB-108 (designed for VTOLs) has extra compressor stage for better economy, more accessories, gear train on air intake casing, and compressor bleed anti-icing. Static thrust is 2750 lb. Right: Napier Eland for Canadair CL-66 uses Blackburn Palouste as air starter.

Spectre in the Saro SR-53 was the first airplane rocket engine to fly that could really be throttled to idling thrust like a turbojet.

Combined with the DH Gyron Jr., this rocket was to have powered the SR-177 Mach 2 naval interceptor. It now is to power the Avro standoff missile, combined with a constant thrust boost version of the Spectre.

An offshoot of the HTP policy for manned rockets is RAE's four-chamber Gamma 201 rocket. Developed by Armstrong Siddeley, it is used in the Saro Black Knight research missile.

Space future for Black Knight?

Fitted with four 4100-4750-lb thrust chambers — each trunnion-mounted for control—the Black Knight may become the second stage of Europe's first satellite launcher. If financed, this vehicle would have a DH Blue Streak LRBM as the first stage and possibly a RAE solid propellant Skylark as the third.

The main task of the Black Knight is to sort out guidance and re-entry problems for the Blue Streak. The latter, now in static testing, is to be powered by Rolls-Royce-built Rocketdyne engines. (Britain's geographical position requires something between an IRBM and ICBM, hence the 2000-2500-mile long range ballistic missile.)

Britain now is the main source for turbine engines in Europe. Last year Bristol Aero-Engines and Armstrong Siddeley Motors merged into Bristol-Siddeley. The merged company about equals Rolls-Royce in plant, manpower, and capital.

Orpheus is an international hit

Bristol-Siddeley now produces the 16,000-lb dry thrust two-spool Olympus for the Avro Vulcan bomber. In development is the 24,000-lb B-O1-7R with Solar afterburner for the TSR-2. The lightweight LPR Orpheus, on the way up from 5000 to 8000 lb thrust with afterburner, is in international use. Powering NATO's standard light ground attack fighter, the G-91, and the Folland Gnat light interceptor, Orpheus is licensed by Fiat, Hindustan Aircraft, and SNECMA. It also is being developed by Curtiss-Wright as the TJ-37.

Bristol engineers see a lot of stretch in the Orpheus, which offers a 6:1 (or better) thrust-weight ratio at an

PRODUCTION Blackburn Palouste air starter cart is used by RAF, Royal Navy, and RCAF.

sfc of around unity. They foresee its applications for jet lift and, because of a low pressure ratio, at high supersonic speeds (without variable compressor geometry).

Armstrong Siddeley's technically interesting P-181/182 reverse-flow, free-shaft turbine (see *AvAge, "P-181 'Copter Turbine Stresses Adaptability," June '58, p.66*) is a 1000-hp unit intended for coupling in a development of the Westland Wessex (the licensed Sikorsky S-58).

Rolls-Royce pushing bypass type

Rolls-Royce's Conway bypass engine — now nearing 20,000 lb dry thrust—is flying in the Victor B2 bomber, the Boeing 707, and the Douglas DC-8. Under development is the scaled-down, 12,000-lb rated thrust RB141 bypass engine. Much of R-R's sales emphasis is on the bypass type's relatively quiet operation (thrust for thrust) and comparative suitability for noise suppressors. R-R has done much work on "silencing" the turbojets and believes the practical limit has been reached in this area.

The 15-in.-diameter RB-108 is the first jet designed to operate vertically for jet lift. By adding a zero compressor stage to improve sfc, R-R has evolved the 2750-lb static thrust RB-145 for the lightweight field.

The two-spool Tyne turboprop is a 5000-shp with many uses. The pressure ratio of 13:1 offers a new low in sfc of 0.388 lb/ehp/hr. The Tyne is off to a good start with orders for BEA and TCA Vickers Vanguards, RCAF Canadair CL-44s, RAF Short Britannics, and N.Y. Airways and BEA Fairey Rotodynes. The field seems clear for it in its class.

Other British turbines are the DH Gyron for the Navy's Blackburn NA-39 low level transonic strike bomber; the Napier Gazelle vertical free shaft design, used in the Bristol 192 and Wessex 'copters; and Blackburn's Turbomeca development, the 1000-hp A-129.

Outstanding in France are the little Turbomecas, while SNECMA has developed the Atar axial flow engines. Turbomecas are licensed in the U.S. and in Britain.

The only practical European STOL craft are the Scottish Aviation Twin Pioneer and Prestwick Pioneer, both well proven in the jungles of Malaya, the single-engine Dornier Do-27, ordered in large numbers by the Luftwaffe, and the French colonial support airplanes. Most promising of the latter is the low wing Morane-Saulnier MS-1500 Epervier (Sparrow Hawk), powered by the 650-750-hp Turbomeca Bastan turboprop. With full-span fixed slots and long conventional gear, this two-seater has a 205-mph speed and takes off from a grass field in 800 ft over a 50-ft obstacle.

Jet flap is leading STOL design

The most promising European contribution to STOL still is the National Gas Turbine Establishment's jet flap design. Industry designers seem scared of its radically new principles. Surprisingly many confuse jet flaps with supercirculation BLC, which has only much narrower possibilities.

Although NACA has done much model testing with jet flaps, its approach has been rather different, involving a greater physical flap area and external jets that blow over the flaps. The British design uses only internal wing ducting. Air is ejected through narrow slits over a five per cent flap that deflects the jet sheet by the Coanda effect. Engine air intakes acting as suction slots along the leading edge to prevent separation bubbles have been suggested.

The basic difference between supercirculation and jet flaps is that, instead of a small amount of compressor bleed air ejected at supersonic speed through minute slits, with jet flaps the whole engine mass flow is ejected at the usual propulsive pressures and speeds. The bypass flow of a bypass jet or the whole residual exhaust of a turboprop are seen as the least that would be used with jet flaps.

Unconventional jet flap controls

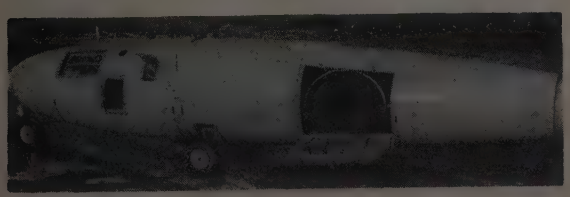
While a jet flap airplane wouldn't look unconventional, it would have to be designed from the start to make fullest use of the new method. The flight control system would be quite unconventional. Lift would be controlled from the engine throttles as a first-order effect through variation of the thrust-lift ratio. The big question is the practicability of the ducting system, including essential cross-overs and multiplication for engine-out safety.

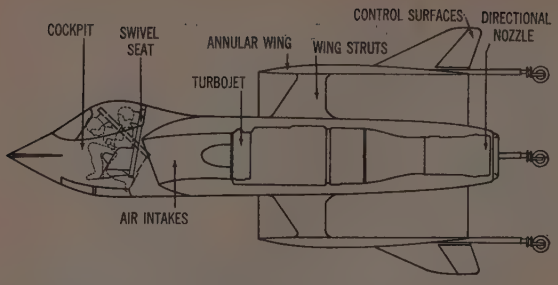
Sud-Aviation has flown two models of the SE-117

more on next page

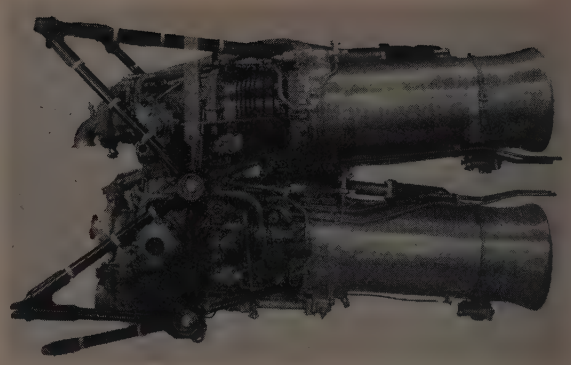
HTP LIQUID rocket built by Bristol-Siddeley for the Black Knight.

BLACKBURN Palouste air starter pod is air-transportable. It weighs 970 lb and is 25 in. in diameter and 150 in. long.





SNECMA Coleopter with annular wing.



DE HAVILLAND Double Spectre rocket can be used by aircraft and missiles. Thrust of top chamber is fixed, that of bottom chamber is fully throttlable.

Voltigeur (Vaulter). The first had Curtiss-Wright Cyclones; the second, 760-hp Turbomeca Bastans. The second prototype broke up in flight, making the type's future uncertain. It seems likely the cheaper, single-engine Epervier will be chosen for close support.

High speed and STOL capability

Heavily armored, armed with two 30-mm cannon, and carrying stores in six underwing racks, the Voltigeur combines high speed with grass strip STOL capabilities. It uses high lift extension flaps and large propellers supplying slipstream air over the wing.

Sud Aviation's SE-112 Diplomatic executive plane uses the same wing, landing gear, and Bastan engines as the Voltigeur. It seats four in luxury, 8-12 in average comfort, and 20 troops in military versions. Takeoff run in 885 ft; takeoff distance over 50 ft, 1200 ft; landing run, 780 ft; climb gradient (with one prop feathered), 3.85 per cent; service ceiling, 31,650 ft; one-engine ceiling, 17,000 ft; level flight speed (with 650 ehp per engine), 320 mph; range, 1250 miles.

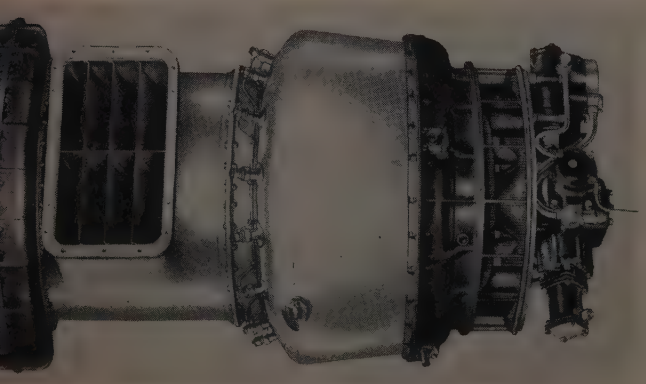
SE-3200 airframe is versatile

The SE-3200 'copter was designed to military specs but with an eye to civil use. The basic airframe is quickly adaptable to different missions. Three 750-hp Turbomeca Turmo III free turbines are claimed to give best compromise between weight, reserve power, and engine-out-safety compromise. Cruise speed at 16,550 lb is 125 mph; max speed, 137; range, 300-600 miles; hovering endurance, 3½ hr.

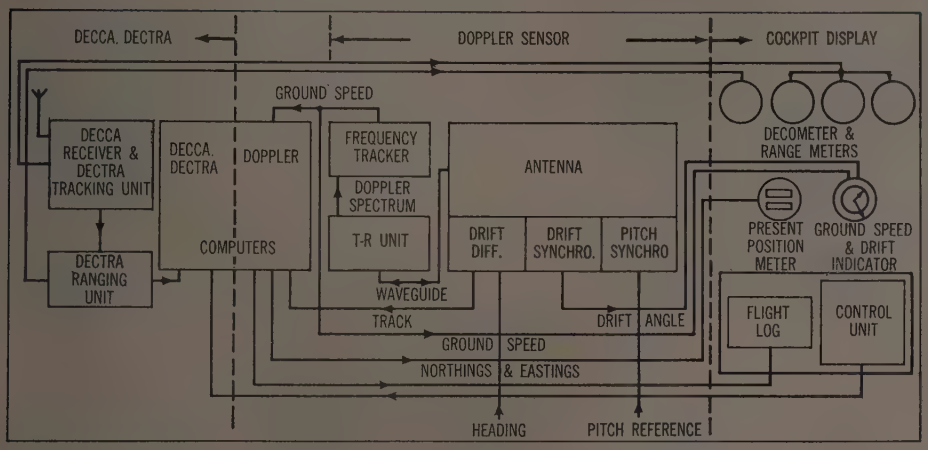
Some progress has been made in the past year in the use of small gas turbines as starters and APUs. Blackburn and General Aircraft, British licensee of Turbomeca, has made a good thing of the Palouste and Artouste engines. It has re-engineered its Turbomecas, fitting a standardized bifurcated intake with multiple accessory mounting pads on all models. Compressor, combustion, turbine, and exhaust units have been arranged for easy interchangeability. There also is an air-transportable pod version.

Two of the small engines, built around the basic Palas centrifugal compressor-turbine power unit (or boiler) with its 3.95 pressure ratio and 7.05-pps air mass flow are the Palouste and Artouste. In France, APU applications are nearly nil. Yet higher capacity Turbomecas, the axial-centrifugal Autan II, delivering three pps at a 5.1 pressure ratio, and the Tramontane, with 5.5 pps at 3.5:1 plus shaft power takeoff, are Available.—End

FIAT'S free turbine Model 4700 air generator for copters. Rating is 542 gas hp at 25,000 rpm for takeoff and 483 gas hp at 24,000 rpm normal.



SNECMA'S Atar Volant (Flying Atar) is first hardware based on the Coleopter principle. In this rig, it is hung upside down—downward protrusion is the cockpit.



DECCA Navigator's Dian system combines features of Decca and Dectran with Doppler design.

Aerospace electronics

in Western Europe

● Growing competition, faster technological pace are giving a new look to electronics firms

by Cyril C. Gee, Editor, British Communications & Electronics

BOTH IN BRITAIN and on the Continent many advances have been made in airborne communications and navigation in the past year. Miniature servo parts, printed circuits, silicon transistors, ferrite components, and tantalum capacitors are helping greatly to improve efficiency and reduce size, weight, and power consumption. Modular construction also is being used more and more. These improvements spring largely from work on guided missiles, but they also add greatly to the reliability of aircraft electronic equipment. Following are some of the latest developments known to be underway, beginning with airborne radar:

• *Marconi's Wireless Telegraph*—As distinct from the earlier military version, which uses pulse transmissions, the AD2300 Doppler navigator uses an FM-CW system. The modulation method is such that the discriminator separates out the locally generated transmissions. Another feature is the use of automatic signal acquisition and memory. The AD2300 also functions in the vertical plane and can be used to measure angle of attack—an attractive feature for military use.

• *Decca Radio*—A civil version of the transistorized lightweight military Doppler Type 61 has been designed to meet Arinc specs. It gives ground-speed up to 1000 knots and drift up to 40 deg left or right. It is claimed to be one of the smallest Dopplers in the world. The radar sensor weighs 651 lb and its computer 151 lb.

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Integration the Keynote

THE CHALLENGE of the common market and greatly increased world competition have brought about a great number of changes in Western Europe's electronics industries.

Behind these changes is the growing realization that, unless more effort is made to pool R&D resources and to find more efficient methods of production and marketing, few firms will be able to keep up with the state of the art. It isn't surprising, therefore, that most large groups and firms are taking stock of their positions. The keynote is integration.

In Britain there are well over 1500 firms in the electronics field. Gross annual product is some $1.3 billion, including about $280 million in exports. Of the total output, some $280 million is produced by the aerospace part of the industry, whose exports in this field come to about $64 million.

Because of defense cuts, many firms in the aircraft industry are making big efforts to break into electronics.

In France, the trend of aircraft companies to develop their own electronics equipment generally is more marked. For example, Dassault, which makes, the Super Mystère and Mirage fighters, has developed telemetry command equipment for engine control and for air-to-air missiles, radar equipment for interceptors, and an extensive range of special servo parts. Other aircraft groups with a stake in electronics, especially for missiles, include Nord, Matra, DEFA, SNECMA, and Sud Aviation.

In the French electronics industry itself, the two largest companies are CSF (Compagnie Generale de Télégraphie Sans Fil) and CFTH (Compagnie Francaise Thomson-Houston). There are some nine other firms in aerospace electronics.

Two of the largest Belgian firms in aerospace electronics are ACEC (Ateliers de Construction Electrique de Charleroi) and MBLE (Manufacture Belge de Lampes de Matériel Electronique).

In Holland, electronics are centered largely at Philips, of Eindhoven and Hilversum. A Philips subsidiary, Hollandse Signaal Apparaten, Hengelo, is well known for its Satco ATC system. An important electronics facility is SHAPE's Air Defense Technical Center at The Hague.

In Switzerland, work on missile electronics is being carried on jointly by Contraves and Oerlikon, both of Zurich. Their designs are also being built under license by Contraves-Italiana, of Rome.

Western Germany is making rapid progress in electronics. The "big three" are AEG, Siemens-Halske, and Hartmann & Braun. Other firms include Brown Boverie, CEIG, Eckhardt, Grundig, Felten & Guilleaume, and Rohde & Schwartz.

All these firms, until lately, have directed their efforts largely to the industrial and domestic markets. Siemens-Halske and Telefunken—a member of the AEG group—are now making inroads into the aerospace electronics.

Farther east, Czechoslovakia and Hungary are the two countries in which the rate of electronics growth is highest. Having started from about scratch after World War II, the industries there are expected to increase to three to four times their present size over the next 10 years. Partly to improve their competitive position in Western markets, the Czechs recently completely reorganized their electronics industry.

• *Decca Navigator*—Great interest has been aroused by the Dian system (*D*ecca *I*ntegrated *A*irborne *N*avigation), which combines the highly accurate area coverage of Decca and Dectra with the self-contained features of the Doppler Type 61. The latest Mark 10 Decca has zone identification, automatic lane identification, and is claimed to remain unaffected by precipitation static.

• *Kelvin & Hughes* (*Aviation*)—A useful addition to Doppler navaids is the map roller Type 2. It lets the pilot fly at high speed accurately at very low altitudes along a predetermined track with a minimum of attention. Up to 30 ft of map may be stored.

• *Ferranti*—Among airborne radars, one of the most advanced is Airpass (*A*irborne *I*nterception *R*adar and *P*ilots' *A*ttack *S*ight *S*ystem). The radar feeds data to a sighting system, which presents the information to the pilot in such a way that he can quickly and easily maneuver into a suitable attack position. The sighting system insures correct aim even though the supersonic target may be invisible to the pilot.

• *De Havilland Propellers*—A special hydraulic scanning unit has been developed for advanced interception radars. It is used for both search and lock-follow, space-stabilized in three axes, and instrumented for feeding data into an autopilot and weapon guidance system.

• *C. G. de Télégraphic Sans Fils* (*CSF*)—This company has made further advances in airborne fire control radars. No details, however, have been released on its latest equipment.

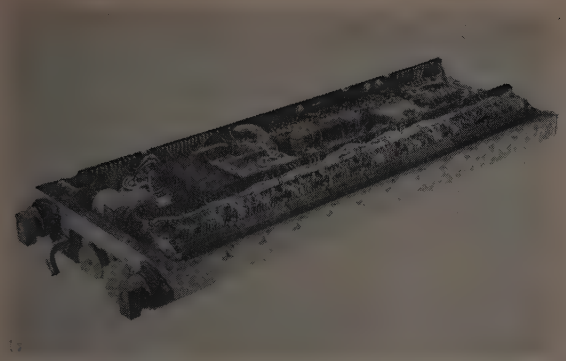
Civil and military ground radars

• *Marconi's*—One major unit is the S264A 50-cm high power airways surveillance and terminal area radar. This 500-kw version of Marconi's 50-kw radar features rain-free performance, long range, exceptionally good MTI, and low cost. Crystal-controlled, it operates on 11 spot frequencies from 585 to 610 mc. Permanent echo suppression is at least 46 db at top range.

Another outstanding development is the S244 long range height finder. Its main features are a high data rate and accuracy at long range. Frequency band is 2700-2900 mc; peak power output, 2½-3 mw (depending on pulsewidth and PRF); mean power output, 2.75 kw max; radar cover (as nodding height finder), 250 nm on a target of 24 sq miles up to 75,000 ft on a 90 per cent probability of paint basis; radar cover as volumetric radar, 230 nm on target of 24 m^2 up to the chosen top angle (say, six degrees from the radar horizon); pulse length, five usec.

The SNG20 fire control radar has a new kind of static-split scanning system and a cassegrain-type antenna. It gives precise position data on high speed targets, with a range up to 35,000 yd and locking on at 25,000 yd. Radio frequency is 9240 $\pm$ 40 mc and peak power output 210 $\pm$ 20 kw.

• *Decca Radar*—The DASR-1 civil air surveillance radar, operating in the 10-cm band, is the latest development in its field. First units are being installed in Stockholm and Gothenburg airports. The 800-kw unit provides gap-free coverage out to 100 nm and to heights above 40,000 ft on the smaller airliners. Performance against a target of 24 m^2 equivalent reflecting area is continuous and gap-free from 110 to 135 miles at 50,000 ft.



SEASLUG GUIDANCE equipment. Seaslug is Royal Navy's first ship-to-air missile. General Electric Co. Ltd., developed and produces the guidance equipment.

PACKAGING of airborne radar for the de Havilland Sea Vixen all-weather naval fighter. Special attention was given to easy maintenance.

• *Thomson-Houston (France)*—The TH-D-1081 air traffic control radar also is designed for the 10-cm band. It works on two separate transmitter-receiver channels, coupled as a "frequency diversity transmitter system"—in normal operation, the two channels operate at the same time on slightly different frequencies. Claimed result is a 20 per cent increase in range and improved continuity of detection within the controlled zone.

The advanced TH-D-1010 precision approach radar (PAR) operates on 9368 ± 10 mc. Peak power is 40 kw; PRF, 2000 ± 20 cps; and pulsewidth, 0.5 = 0.1 usec at 90 per cent peak value. The TH-D-891 circular polarization panel can be added to help reduce rain clutter effects. The control desk has two displays—one for 20 km (12.42 miles) minimum and for five km (3.1 miles). Both fixed and mobile versions are available. Either can be remotely operated at distances up to three km (1.86 miles).

• *A.E.I. Military Electronic Apparatus Group*—Ground radars under development include tactical control acquisition, and target tracking illuminating system. A system of last type, the Sting-Ray, is the primary guidance radar of Britain's first missile base and is also being included in the Swedish ground-to-air defense program. Its job is to acquire a target as quickly as possible, track it with great accuracy, and illuminate it so that ground-to-air missiles such as the Bloodhound and Thunderbird can home on the target.

• *Cossor Radar & Electronics*—The GR-21 radar operates in the S-band over ranges of 10, 25, 50, and 100 nm. A remotely controlled circular polarizing plate eliminates rain echoes. Provision is made for fitting secondary radar integrating transmitter-receiver units and antenna arrays.

A 25 per cent increase in range can be had by using the new CR787 equipment. This includes a microwave amplifier to increase system performance by some 40 db.

• *Contraves, Munich*—The Fledermaus (Bat) fire control unit, designed to NATO specs, consists of a target acquisition radar, a one-man visual tracker, a tracking radar, a computer, and a carriage. In conjunction with the Albis AFR 150 radar (with a minimum power of 150 kw), acquisition of targets can be acquired at distance from 0.3 to 50 km (0.19-31.05 miles); with the Albis AFR50 radar (minimum power, 50 kw), the range is 0.3-40 km (0.19-24.84 miles). The maximum automatic tracking ranges are 10 km (6.21 miles) shorter.

Measurement of present data-bearing elevation and start range are dynamically highly accurate. These values are fed continuously to the computer. Individual firing data can be determined for two or three gun emplacements. The unit is simple to operate, easy to service, and can be positioned by three men in about five minutes.

• *Standard Telephones & Cables (STC)*—One of the latest developments is the SLA-3 PAR. The precision-built antennas are under cover, fully protected from weather. The display system includes two 17-in., high definition rectangular CRT screens. It is said that the high degree of reading accuracy obtainable with these tubes makes the SLA-3 the most advanced PAR in the world. SLA-3s are installed at Stockholm.

Secret guidance and control systems

Details of guidance and control systems are very closely guarded in both Britain and on the Continent. The Bristol-Ferranti Bloodhound missile, nearing full operational status with the RAF, uses a semi-active homing system. It may be fired singly or in salvos, using one ground radar.

The de Havilland Firestreak air-to-air missile, ordered as standard equipment by RAF and Navy, uses Mullard infrared homing—on the grounds of its long range, high sensitivity and immunity to jamming. Guidance for the Seaslug, the Navy's first ship-to-air missile is mainly the responsibility of General Electric Co. Ltd.

Problems of homing are being studied by the Ministry of Supply with the Short-Elliott GPV rocket test vehicle. Short Bros. & Harland also has developed a target version of the English Electric Canberra B Mk 2. The aircraft has flown above 50,000 ft under full automatic control.

Wide range of navcom equipment

• *STC*—Major advances are represented by the fully transistorized STR-23/34/35/36, a comprehensive VHF-ILS-VOR unit; the SA-10 audio control and in-

more on next page

MARCONI S244 long range height finder radar features high data rate and accuracy.

tercom; the FM subminiature radio altimeter; and a four-channel MF airborne radioteleprinter. The last operates over 90-135 mc and weighs 45 lb. The teleprinter, good for 100 words a minute, was specially developed by Creed.

• *Mullard*—The X-7443 single-side band transmitter-receiver was developed to fill the need for a compact, long range, pilot-operated radio-telephone. Its peak power output of 300 W is equivalent in range to a double-sideband carrier's 2.5 kw or more. Other characteristics are: frequency range, 2.5-20 Mc; 12 preset, crystal-controlled channels; frequency stability, about ± 1 part per million for normal input voltage and ambient temperature variations; weight, 85 lb.

• *McMichael Radio*—The Type 1945 transmitter can be dropped from an aircraft with aid of a small chute into the sea at 200-5000 ft and airspeeds of up to 200 knots. It is basically a buoy containing equipment for detecting underwater sounds and transmitting them to the aircraft. Total weight, with batteries for at least four hours' operation is 17½ lb.

• *CSF*—The latest development is the fully transistorized RC232 automatic radio compass. It weighs less than 13.22 lb. Main design features are easy installation and maintenance and small size. Frequency coverage is 200-800 kc on four ranges; accuracy is ±2 for a field of 25 Uv/m.

IR developments in Britain, France

Britain's main R&D center for IR detection is the RRE, at Malvern. It has experimented with germanium doped with concentrations of impurities such as phosphorous, arsenic and antimony. An antimony-doped germanium element, cooled in liquid helium at 4.2 deg K and fully shielded, has a resistance of 500 K. Mounting reduces this to 30-50 K. Using a "glow bar" source with suitable filtering elements and a grating monochromator, the detector is sensitive to beyond 11 microns. IR detecting devices using crystals of several compound semiconductors also have been developed by Plessey.

• *Mullard*—A late development is the ORPIO indium antimonide photoconductive cell, sensitive to IR radiation up to 7.5 microns, at 20 deg C. Minimum detectable power is less than 4 millimicrowatts at six microns; bandwidth, one cps; time constant, less than one usec; maximum direct current 100 mc; cell resistance, 75 ohms; maximum case temperature, 70 deg C. Other IR detectors include the 63TV cooled lead telluride cell, with its peak response at 4.5 microns; the uncooled lead selenide cell 61RV, with high sensitivity in the 3-4.5-micron region; and the 61SV uncooled lead sulphide cell with maximum sensitivity at 2-3 microns.

• *Turck* (*Cachan, Seine*)—Advanced work is being done on cells of lead telluride (peaks at four microns), lead selenide (useful output at six microns), lead sulphide (peaks at 3-3.5 microns), and antimonide and also on a bolometer-type detector suitable for use up to 15 microns.

Research in automatic landing

The system developed by RAE's Blind Landing Experimental Unit (BLEU) at Bedford, lands the aircraft automatically, with the pilot acting only as monitor. More than 2000 successful landings have been made. The BLEU system uses an autopilot, basically similar to Smith's SEP2, Pye's ILS ground equipment, STC's airborne SR14/15-B, the STR30-B1 radio altimeter, and Murphy Radio's magnetic leader system. The last insures accurate azimuth guidance during the critical landing stage. During all landing phases, monitoring signals are displayed on the normal flight instruments forming part of the Smith's flight system. The first new transport to use BLEU will be the Vickers VC-10.

Techniques mated in special units

• *General Electric*—An experimental four-way microwave switch uses gaseous discharge plasma to bridge gaps between the inner conductor of the common coaxial line and that of one of the other lines. It operates over 600-4000 mc with a loss of less than three decibels.

A new type of induction digitizer, developed in connection with missile work, may apply to airborne computer systems. It consists basically of a transformer with a single exciting winding and a number of secondary windings corresponding to the number of digits. Instruments for five-digit readout in a standard size 11 synchro housing have been made and for seven-digit readout in a size 23 synchro.

Considerable savings in weight and easier production are made possible by the salt bath brazed metal waveguide construction method. The method is said to be especially suitable for complex circuits in aircraft and missiles.

• *S. d'Electronique & d'Automatisme*—A new form of extremely low inertia servomotor, the Servalco, uses no iron in the armature structure. The armature con-

sists of a thin disk of insulating material on which ribbon-like copper conductors are printed. The printed armature is mounted in a planary air gap machine using Alnico permanent magnets. Low-voltage-drop silver-graphite brushes ride directly on the bare surface of the armature conductors. Shaft output powers may range from a few watts to several kilowatts. The small motor weighs 10 oz and is 62 mm in diameter and 42.5 mm wide. Maximum stalling torque is 13 oz-in.

Widespread work in microwave field

In Britain, SRDE and RRE, two government agencies, are working on masers and various solid state materials for generating microwave signals. SRDE for some time has been operating an ammonium maser as an accurate frequency source. One such maser, which generates a frequency of about 23,870.13 mc, is being produced by Ultrasonascope (London).

One of the latest RRE developments is a three-level paramagnetic maser. It uses energy levels produced in a paramagnetic substance placed in a magnetic field. The crystal is kept at liquid helium temperature.

• *E.M.I. Electronics*—The R5222 is a low voltage, reflex speed modulated, plug-in X-band klystron oscillator designed for operation with an external cavity. In suitable cavities, the valve may be used at frequencies of 5000 mc and as high as 12,000 mc. Wide range cavities with 35 per cent tuning range area available over this band. Particularly interesting in the millimeter range is the packaged R9551 magnetron for O-band pulse generation.

• *English Electric Valve*—The K350 two-resonator oscillator klystron is ideal as a transmitter for CW and FM-CW airborne Doppler. It puts out one watt at X-band with good linearity and very low residual FM noise. The K308 reflex klystron is suitable as an X-band local oscillator in airborne systems for which good frequency tracking of the local oscillator and magnetron is required over relatively large temperature ranges without changes in mechanical tuning. Where robustness is required, the K337 and K342 give suitable performance as X-band local oscillators.

• *Mullard*—Microwave tubes in the pre-production or development stages include: BA9-20 X-band backward wave oscillator, voltage-tunable over 7000-11,500 mc with a maximum voltage of 1.4 kv and a minimum output of 20 mw; BA16-10 backward wave oscillator for J-band, with a minimum output of 10 mw over 11,000-18,000 mc and a maximum voltage of 2.5 kv; BA3-30 for S-band, with a minimum output of 30 mw over 2400-4500 mc and a range of 150-1500 V; VX8515 high power multi-cavity klystron amplifier for X-band, with a gain of 50 db, a bandwidth of 100 mc, a peak output of 250 kw, a duty cycle of 0.001, a beam voltage of 64 kv, and a beam current 16 amp; and KS7-1C reflex klystron for 6875-7125 mc, with a power output of 1.1 W.

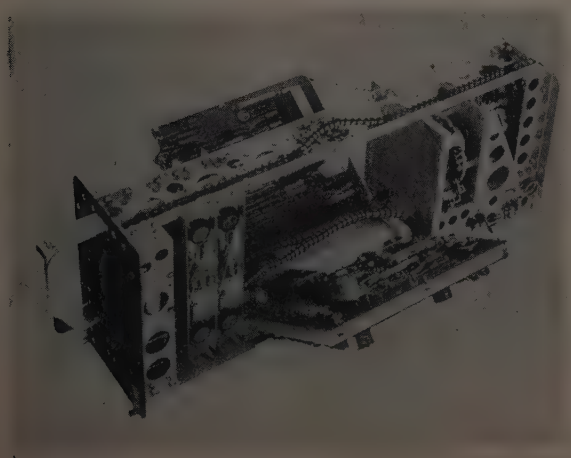
Also in development is a fixed frequency miniature S-band magnetron for 2850 mc; with a peak power at two kv of 200 W and a duty cycle of 0.002. The valve is little larger than a matchbox and weighs only 3½ oz fully packaged.

• *Telefunken*—Work is continuing on multi-gap klystrons. These are said to be especially favorable for extremely short wavelengths, because of their high resonance resistances and low circuit losses. In comparison with a reflex klystron of the same efficiency, the multi-gap type is said to be superior in bandwith; with designs of the same bandwith, it reportedly is superior in efficiency.

• *CSF*—The extensive range of the carcinotron tubes continues to attract world attention. CSF's types now cover a frequency range of 1000-37,500 mc.

The CO1308X has a power output of about five mw between 23,500 and 37,500 mc. As in most carcinotrons, the frequency varies continuously as a function of the line voltage without hysteresis or lack of oscillation. The frequency variation due to pulling is said to be very low. Another fairly recent tube, the CO2012X, has a power output of about 10-50 mw between 15,500 and 24,000 mc.

FULLY TRANSISTORIZED frequency tracker of the Decca Navigator DIAN Doppler radar system.



Both analog and digital computers

General-purpose analog computers are being offerd by Cape Electrophonics, E.M.I., English Electric. Fairey, Metropolitan-Vickers, Saunders-Roe, Short Bros. & Harland, and Solartron. For research and design work, much use also is being made of digital computers, notably the English Electric Deuce and the Ferranti Mercury.

• *A. V. Roe*—A recent unit is the Addam II (*A*vro *D*igital *D*ifferential *A*nalysing *M*achine). Small, reliable, and with low power consumption, this fully transistorized type could be adapted readily for airborne use.

• *Kelvin & Hughes*—An air data computer measures basic aerodynamic quantities and from these computs barometric height (from —1000 to 100,000 ft); rate of change of height (from six to 60,000 fpm); indicated air-speed (from 70 to 800 knots); Mach number (from 0.3 to 3); and true air-speed (from 200 to 1600 knots).

• *Plessey*—A pressure ratio computer, or angle of incidence indicator, measures and indicates angle of incidence in high speed jet aircraft. It is a force-balance system using two capsules, one sensitive to stagnation pressure and the other to underwing pressure.—End

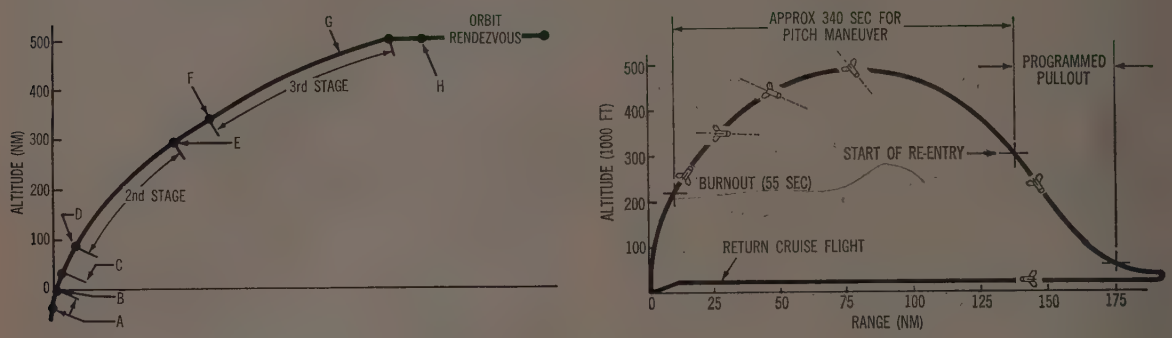


FIGURE 1: Boost sequence (left): (A) pre-launch check-out; (B) start turbojets, start rocket turbopumps, ignite first-stage booster; (C) shut down first-stage booster, separate first stage; (D) ignite second-stage rocket, start turbopumps, ignite second-stage ullage rockets; (E) shut down second-stage rocket, separate second stage; (F) ignite third-stage ullage rockets, start turbopumps, ignite third-stage rocket; (G) ignite third-stage verniers, shut down third-stage rocket; (H) shut down vernier rockets. Right: Recoverable booster's first stage reaches 5200 fps above 200,000 ft at 55-deg angle burnout. Second stage burns to about 300 nm, with 15,200 fps. Final stage goes into orbit at 500 nm, with a total velocity of 24,240 fps.

Booster design

for a 20,000-pound satellite

This is the first article in a series that will analyze in detail the requirements of a multi-manned satellite based on the current state of the art. Future articles will deal with the design of the space station, the space operations vehicle, and the re-entry vehicle involved in the overall system.

by S. B. Kramer and R. A. Byers,
Space Vehicle Design Scientist & Staff Engineer, resp., Missiles & Space Div., Lockheed Aircraft Corp.*

WITHIN TEN YEARS, we could develop and build the equipment needed to launch and support a multi-manned satellite in a 500-mile-high orbit. Many of the subassemblies are already in use or under development.

The starting point of a booster system to put up payloads of up to 20,000 lb (*Fig. 3*) would consist of a three-stage vehicle 180 ft long and with a base of 18 ft. Takeoff weight, including payload, would be close to 700,000 lb.

A preliminary detail design has already been worked out (*Fig. 2*). For safety, the ultimate design loads are 150 per cent of the limit loads. The basic structure is designed to withstand a five-G limit longitudinal acceler-

*Missiles & Space Div., Lockheed Aircraft Corp., Sunnyvale, Calif. This is a condensation of a paper, "Proposal for the Assembly of a Multi-Manned Satellite," given at the national meeting of the American Astronautical Society in Washington, D. C., last December 27-30.

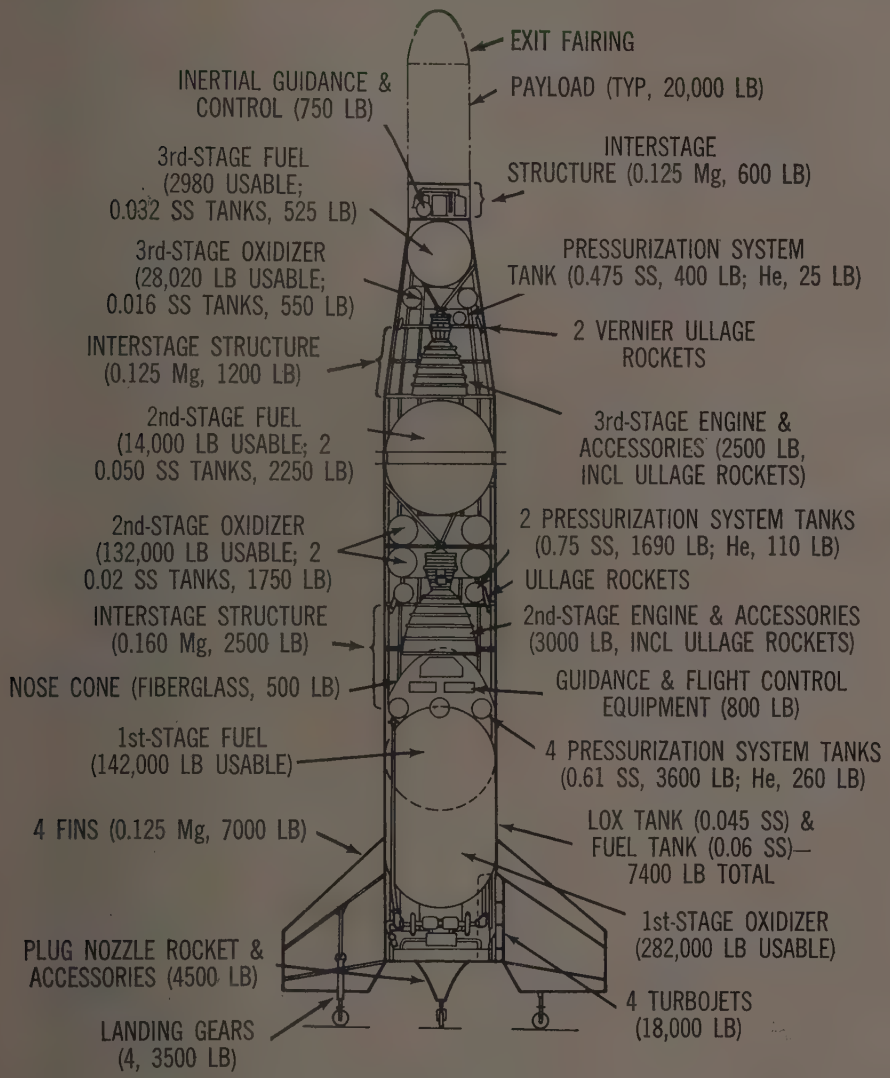

EXIT FAIRING
PAYLOAD (TYP, 20,000 LB)
INERTIAL GUIDANCE & CONTROL (750 LB)
INTERSTAGE STRUCTURE (0.125 Mg, 600 LB)
3rd-STAGE FUEL (2980 USABLE; 0.032 SS TANKS, 525 LB)
PRESSURIZATION SYSTEM TANK (0.475 SS, 400 LB; He, 25 LB)
3rd-STAGE OXIDIZER (28,020 LB USABLE; 0.016 SS TANKS, 550 LB)
2 VERNIER ULLAGE ROCKETS
INTERSTAGE STRUCTURE (0.125 Mg, 1200 LB)
3rd-STAGE ENGINE & ACCESSORIES (2500 LB, INCL ULLAGE ROCKETS)
2nd-STAGE FUEL (14,000 LB USABLE; 2 0.050 SS TANKS, 2250 LB)
2 PRESSURIZATION SYSTEM TANKS (0.75 SS, 1690 LB; He, 110 LB)
2nd-STAGE OXIDIZER (132,000 LB USABLE; 2 0.02 SS TANKS, 1750 LB)
ULLAGE ROCKETS
INTERSTAGE STRUCTURE (0.160 Mg, 2500 LB)
2nd-STAGE ENGINE & ACCESSORIES (3000 LB, INCL ULLAGE ROCKETS)
NOSE CONE (FIBERGLASS, 500 LB)
GUIDANCE & FLIGHT CONTROL EQUIPMENT (800 LB)
1st-STAGE FUEL (142,000 LB USABLE)
4 PRESSURIZATION SYSTEM TANKS (0.61 SS, 3600 LB; He, 260 LB)
4 FINS (0.125 Mg, 7000 LB)
LOX TANK (0.045 SS) & FUEL TANK (0.06 SS)— 7400 LB TOTAL
1st-STAGE OXIDIZER (282,000 LB USABLE)
PLUG NOZZLE ROCKET & ACCESSORIES (4500 LB)
4 TURBOJETS (18,000 LB)
LANDING GEARS (4, 3500 LB)

FIGURE 2: Booster propulsion detail. First stage has a gross weight of 474,460 lb, a re-entry weight of 60,460 lb, and a landing weight of 50,460 lb. The body structure of 0.25 magnesium weighs 3200 lb.; the residual propellant, 1000 lb. The design allows for an added weight contingency of 700 lb. The second-stage body structure of 0.16 magnesium weighs 4800 lb; the residual propellant, 1000 lb; the contingency allowance is 500 lbs; gross weight, 163,550 lb; and burnout weight, 17,550 lb. The third-stage body structure of 0.125 magnesium weighs 1300 lb; the residual propellant, 750 lb; the contingency allowance is 500 lb; gross weight, 38,300 lb; and burnout weight, 7300 lb.

ation in combination with air load movements varying almost linearly from zero at the nose of the payload to 2,000,000 ft-lb at the launch CG 125 ft from the nose. From there on aft, it is assumed the design limit moment remains constant.

At launch, the vehicle rests on the aft ring of the body. The fin-landing-gear arrangement helps stabilize it against overturning moments but is designed primarily for recovering the first stage. Landing loads should not be critical, since the first-stage weight of 52,000 lb is less than eight per cent of the launch weight.

The recoverable first stage provides a bit more than 1,000,000 lb thrust to lift the system above the atmosphere. Second-stage thrust adds over 300,000 lb in the exosphere. There follows a third stage, which lifts and verniers the payload into orbit (*Fig. 1*).

Basically, the first-stage system is quite similar to the "plugged nozzle" design being developed by General Electric. Sea level thrust is 1,160,000 lb at a chamber pressure of 600 psia. The burning time is about 90 seconds.

Using a manifold chamber design permits a weight saving of 10-20 per cent compared with a large, single-chamber design. Overall chamber length is also considerably less. Tanks are an integral part of the structural design, with the tank wall used to transmit first-stage loads. The propellant lines are shut off at burnout to retain pressurization in the tanks, which therefore can sustain re-entry and flight loads during recovery. (The pressurization system uses helium gas at 4500 psia.)

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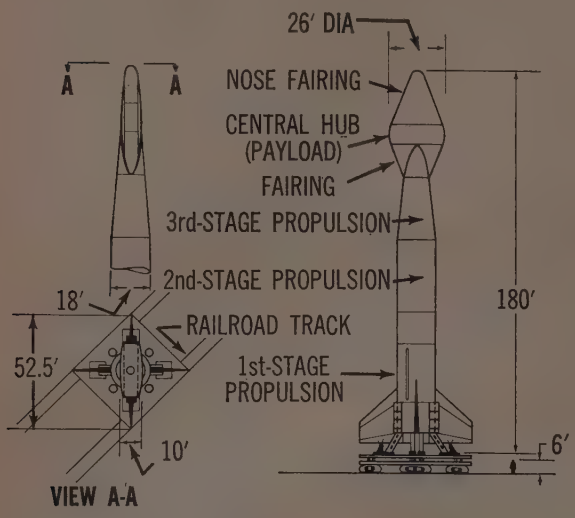


FIGURE 3: Three-stage booster vehicle to put 20,000-lb payload into 500-mile-high orbit. The first stage has a turbojet assist for takeoff boost and recovery flight.

Overall System Weights

	Weight	Percentage of Total Weight
Launch gross weight	699,610	—
First-stage burnout weight	285,610	—
Second-stage gross weight	222,650	—
Second-stage burnout weight	76,650	—
Third-stage gross weight	58,900	—
Third-stage burnout weight	27,900	—
Payload weight	20,000	—
Impulse propellant	601,000	85.9
Propulsion system (dry)	49,310	7
Structure	24,300	3.5
Equipment	3000	0.4
Payload	20,000	2.9
Contingency allowance	2000	0.3

Four turbojets are mounted on the aft fuselage of the first stage. Although they are used during ascent through the atmosphere, their primary purpose is for recovery of the first stage. Fins, used to stabilize the missile during ascent, provide the lift for the return flight back to base.

The turbojets produce a maximum sea level thrust of at least 25,000 lbs each. They are ignited just before launch and continue to operate up to about 100,000 ft, where they are automatically shut off. After re-entry, they are re-ignited to power the return flight.

In case one engine flames out, gas jet deflectors provide compensating moments to balance any thrust asymmetry. Over the launch site, the booster is oriented into a vertical attitude for setdown, with the turbojet thrust regulating the rate of descent.

The primary propulsion system for the second stage consists of a single regeneratively cooled thrust chamber operating at 150 psia and equipped with a bell-shaped nozzle. The nozzle expansion ratio is 25.

Instead of the liquid oxygen-hydrocarbon propellant combination used in the first stage, the second-stage system burns a pump-fed hydrogen-fluorine mixture with an oxidizer-fuel ratio of about 9.5. This ratio gives a relatively high specific impulse, while keeping the hydrogen volume down. (At lower mixture ratios, the fuel tank volume becomes excessive, because the specific weight of hydrogen is so very low.) The rocket produces 321,000 lb of vacuum thrust and burns for 200 seconds.

The fuel tank is made of high strength stainless steel in the form of a short cylindrical section with hemispherical ends. With an outer insulation, hydrogen boil-off is practically nil for 20-30 minutes under three atm.

Toroidal tanks shorten vehicle

The fluorine tanks are toroidal. This makes them heavier than spherical tanks but also makes the vehicle shorter. Made of High strength stainless steel, the tanks are jacketed with aluminum tanks containing liquid nitrogen. Since the liquid nitrogen is at a lower temperature than the fluorine, it keeps the oxidizer from becoming warm and boiling off. The fluorine tank pressure is also about three atm.

In addition to the main rocket, the second stage contains two small solid propellant "ullage" rockets weighing about 100 lb each. They produce 4000 lb of thrust for 10 seconds to accelerate the second stage at about 0.018 G. and so make sure the propellant located in the aft end of the tanks and bubbles are kept out of the flow lines.

The third-stage rocket is quite similar to the second-stage one, except that it is smaller. It has a thrust of about 76,000 lb, a burning time of 175 seconds, and a nozzle expansion ratio of 35. The propellant combination is the same, and the tankage is quite similar. Two 60-lb ullage rockets supply about 1200 lb thrust for 10 seconds' acceleration at about 0.02 G.

A major difference is that the third stage also has two vernier-controlled liquid propellant rockets for regulating the final velocity vector and to maneuver the payload in orbit. They use a storable, hypergolic mixture of fluorine and hydrazine.

Aerodynamic stability of the first stage is no problem. However, at high altitudes the effectiveness of the tail fins is greatly reduced, so an attitude control system must be used to regulate the peripheral flow of the main rocket exhaust. Reducing the flow rate at one side

Booster Propulsion System	First Stage	Recovery System	Second Stage	Third Stage
Propellant weight (lb)	409,000	15,000[1]	146,000	31,000
Oxidizer-Fuel Ratio	2.28	—	9.5	9.5
Oxidizer	oxygen	—	fluorine	fluorine
Fuel	hydrocarbon	—	hydrogen	hydrogen
Feed system	pump	pressure	pump	pump
Pressurized gas & weight	He, 260 lb	—	He, 110 lb	He, 25 lb
Specific impulse (sec)	252[2]	—	420[3]	430[3]
Total impulse (lb-sec)	126×10^6	—	61.4×10^6	13.33×10^6
Expansion ratio	8	[4]	25	35
Chamber pressure (psia)	600	—	175	175
Thrust (lb)	1.15×10^6	40,000[5]	321,000	76,000
Burning time (min)	1½	23	3½	11/12

(1) For turbojets (2) At sea level. (3) In vacuum. (4) SFC of 0.9. (5) Cruise.

causes an asymmetrical force that produces a corrective pitch or yaw moment. Auxiliary reaction jets are used for roll control.

Ascent aerodynamics are rather straightforward. After a vertical launch, the first stage flies a moderate pitch program to achieve the most desirable exit flight conditions at a burnout velocity of 5200 fps. Separation takes place above 200,000 ft, where the dynamic pressure is very low. The dynamics of separation therefore are not critical.

After the first separation, the second stage ignites and continues to carry the payload to orbit altitude. Meanwhile, the first stage booster coasts on above the atmosphere in a free fall and is oriented for re-entry (*Fig. 1*).

The first stage will slow down to subsonic speeds and level off to fly back to the launch base at about 25,-30,000 ft. The drag, on the order of 40,000 lb, is easily overcome by the four turbojets.

The second-stage rocket accelerates the payload to about 15,200 fps at about 300 nm. At this altitude, the final propulsion stage separates and then adds another velocity increment of about 9040 fps. (As presently conceived, the second stage is jettisoned but it could be recovered—if its empty weight were 7-10 per cent higher.)

The interstage structure is designed so that the two separation planes are about 15 ft apart. Explosive cord is placed inside the skin at the circumference of each separation plane. Four more cords are equally spaced along the length of the separation section. At about 220,000 ft altitude and a 55-deg trajectory angle, the prima-cord is detonated. The 15-ft separation section breaks into four pieces, which are blown away from the ship.

At that altitude, the atmosphere still exerts an appreciable amount of drag on the skin. As a result, a 10-15-second time lapse is used to let the vehicles separate. (The recoverable first stage has a higher drag-weight ratio than the rest of the vehicle.)

At the end of the 10-15-second wait, the second-stage ullage rockets are fired. After another five seconds (with the fuel now in the correct position), the second-stage propulsion system is fired, completing the separation sequence.

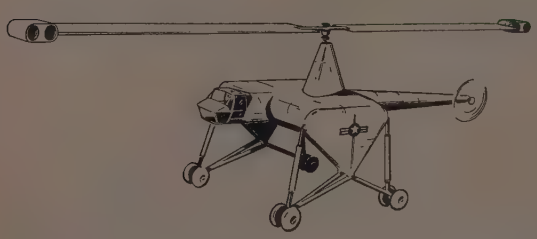
The second separation takes place at 300 miles altitude and a 20-deg trajectory angle. The same explosive cord technique is used for separation. But this time the third stage ullage rockets are fired as soon as the four pieces are blown away. After five seconds, the third-stage propulsion system is then activated.

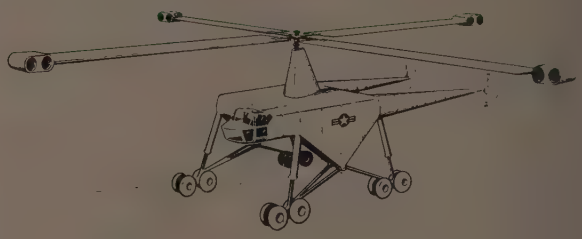
The second and third stages are inherently unstable. They are controlled by gimbaling the main thrust chamber for thrust vector control and by reaction jets for roll control.

Separate guidance for recovery

For recovery, the first booster stage needs a separate guidance system of its own to stabilize and program it through re-entry. This system's main elements are an inertial platform and time-reference programmer as the basic intelligence source, a controllable hydrogen peroxide reaction jet for attitude control, and a conventional aerodynamic control surface system.

After the first stage is separated, the inertial stabilizing unit pitches the airframe to an optimum re-entry attitude and also provides roll and yaw stabilization throughout the flight program. The programer is set to vary vehicle attitude with decreasing altitude and increasing dynamic pressures. At 30,000 ft, it is superseded by a ground command, which makes course and attitude corrections to direct the first stage to a landing site. Hydraulic and electric power are needed for exit flight, re-entry and return to base.—End





TWO-BLADED, four-engine, 60,000-lb-gross Model 1089A (left) and four-bladed, eight-engine, 120,000-lb-gross Model 1089B have been proposed to services by Hiller as prototypes for rotor-tip-mounted turbine program.

Rotor tip turbojets revive interest in large copters

In the past, large transport helicopters (of over 25,000 lb gross) haven't looked too promising—studies showed empty weight increased faster than payload with increasing gross weight. Now, though, it's become possible to design such craft with good payload-gross weight ratios.

by Irwin Stambler Associate Editor

THE DEVELOPMENT of efficient small jet engines is bringing about radical changes in many areas of aircraft design.

In the helicopter field it has, remarkably enough, led to renewed interest in large transport and crane types. This trend is well represented by the designs that Hiller Aircraft Corp., of Palo Alto, Calif., working in conjunction with Continental Aviation Engineering Corp., of Detroit, Mich., has proposed for a new series of copters powered by rotor-tip mounted turbojets.

The basic powerplant for these large craft would be Continental's J69-T-29, which has a weight of about 300 lb (including nacelles for single-engine installation). It will develop about 1925 net rotor hp at a rotor tip speed of about 700 fps.

As John Nichols, of Hiller's Engineering Div., pointed out to SPACE/AERONAUTICS, earlier test vehicles, such as the Hughes XH-17 and XH-28 and the Vertol YH-16 tandem rotor design, proved the feasibility of large helicopters. It was the types of 'copter powerplants available at the time that presented the real problem.

Good gear-type transmissions, Nichols notes, require a great deal of development work. This is expensive for small copters, he states, and almost prohibitive for large ones. Ramjets and pulsejets, don't have the gearing problem, but their high fuel consumption tends to limit them to short ranges. Pressure jet systems, say Hiller researcher, have ducting problems that don't affect tip-mounted turbojets, and they may also require difficult rotor system changes.

Hiller's faith in tip jet designs stems in part from experience gained with its 1952 H-32 ramjet-powered Hornet. This design provided the knowhow on living with high-G loadings, flow problems, etc. Its success naturally led to the suggestion to replace the ramjet with a low-fuel-consumption engine such as a turbojet. Proposals were submitted to the services based on specially designed turbojets for tip mounting on copters of over 25,000 lb gross weight.

Studies of possible designs of this type were undertaken by Hiller in 1956 under contract to the Office

of Naval Research. Engine support work was first provided by Studebaker-Packard and was later transferred to Continental. Configurations were studied for 25,000, 60,000, and 150,000 lb gross. Later a 12,000-lb-gross type was added to make sure Hiller would pick up the crossover point at which the tip turbine showed gains over other installations.

The program's next development came in the rapidly progressing turbojet field—efficient small engines became available. These at once solved many of Hiller's problems. For the first time, Hiller engineers state, it became feasible to get a tip-mounted engine by changing to a conventional type instead of designing a brand-new engine.

Rotor weight increases slowly

Figure 2 shows that the weight-thrust ratio of small turbojets minimizes at about 2000 lb thrust—about the right figure for a 25,000-lb-gross copter. Since higher specific weights would have been needed for lower gross weights, Hiller dropped the 12,000-lb-gross design from its study. Another reason for not considering gross weights under 25,000 lb, it's pointed out, is that successful shaft-driven engines are available for this range. For copters over 25,000 lb, you don't have to pay the weight-thrust penalty indicated in *Figure 2*, because multiples of the most efficient type of powerplant can be used.

Figure 1 shows, Hiller engineers state, that the rotor system-gross weight ratio increases faster for shaft pressure jet systems than for tip turbojets. The primary reason for this, they note, is that the weight of the tip engine is compatible with optimum rotor blade design. A tapering-mass rotor is really called for, but most designers of conventional copters for production reasons don't use such a design.

There is almost no weight penalty

However, with larger copters, Hiller engineers say, it becomes more economical to use thinner and thinner metal sections towards the rotor tip. Another factor is that the lift force on the blade tends to increase the bending moment at the hub, requiring the use of tip weights to keep the coning angles down. Since the tip turbojet comes very close to the optimum tip weight, the latter is eliminated. These factors, say Hiller engineers, mean that tip jet designs give you the powerplant almost free so far as additional weight is concerned.

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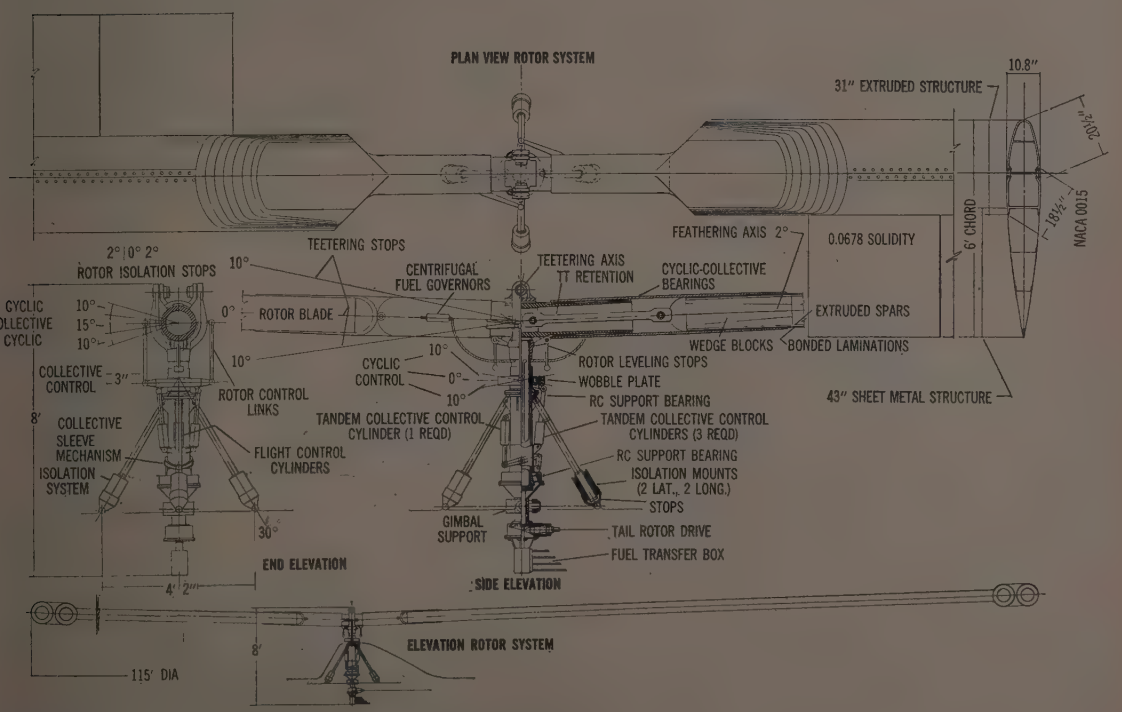


ROTOR HUB system for Hiller-Continental tip turbine 'copter.

MISSILE RESUPPLY copters are a possible future application of this tip turbine principle.

Hiller's program also indicates that it is in the nature of tip-applied power to eliminate the need for engine torque compensation. Otherwise, it's claimed, increasingly longer and heavier tail would have to be used. Hiller's studies indicate that no tail rotor, or only a small one on a short tail boom is needed for tip-powered designs.

Two configurations were proposed

As a result of Hiller's program, two prototypes have been suggested to the services for use as combination crane, cargo, and personnel vehicles. One has a gross weight of 60,000 lb and an empty weight of 30,000 lb in the transport configuration. The stripped crane version would save about 25 per cent of the body weight. Useful load would be a 12-15-ton payload for a typical crane mission, 40 passengers, or five tons of payload for a 200-nm-radius transport operation.

The cargo or passenger payload could be moved into position in a roadable gondola arrangement, with fittings in the roof for attachment to the underside of the copter fuselage. The copter would use two rotor blades, each with twin podded engines at the tips. It's designed for 6000-ft hover at gross weight on a standard Army hot day (95 deg F) and for cruise with only one of the two engines on each blade in operation.

No hot-gas ducts in the rotor

The second suggested version has a gross weight of 120,000 lb, providing a crane range of 25 nm with 20-27 tons of payload. It can also serve as an 80-passenger transport or carry a 10-ton cargo over 200 nm. The basis of this design is that four twin-podded engines will roughly double the payload capabilities of the basic configuration.

One advantage of the tip turbojet design is that no provisions are needed for ducts in the rotor for hot gases. This eliminates the need for high temperature materials or extra thickness for ducts, it's claimed. Since conventional materials and thin sections can be used, SPACE/AERONAUTICS was told, the design wasn't restricted in forward speed any more than are conventional types. Hiller's design studies were based on a forward cruise speed of 120 knots for passenger and cargo operation. The company's also noted that its engine setup eliminates the need for complex equipment in the fuselage—so the copters could be folded up to fit into transport aircraft, such as the C-130 or C-133.

Interchangeability was stressed

Another goal of the program was to have interchangeability of components between the various sizes of vehicles. For instance, all the proposed engine assemblies are intended to be identical. The 120,000-lb model would use two rotor assemblies identical to the one used on the 60,000-lb copter. They would be mounted one above the other at a 90-deg angle on the same shaft.

The boom, tail rotor, and tail rotor drive for both

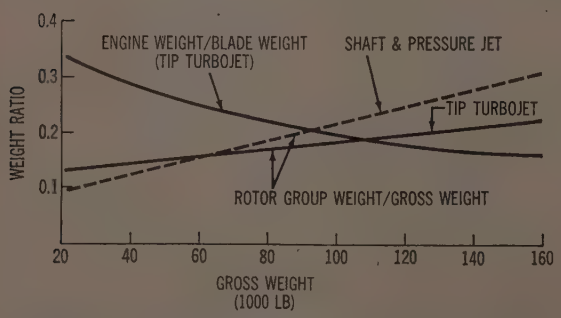
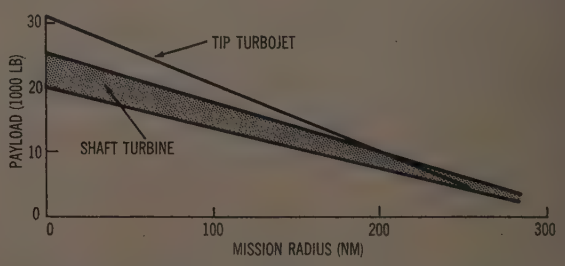


FIGURE 1: Hiller curves show rotor group weight-gross weight ratio for different jets.



PAYLOAD capabilities of tip turbine copter with 60,000-lb gross and 6000-ft hover ceiling at 95 deg F, Hiller curves show, are superior to those of a shaft turbine design for up to 2000 nm mission radius.

versions would also be the same, except that the larger copter would use two tail booms and the smaller only one. The two booms could be mounted to provide longitudinal CG control by means of collective pitch applied to the two rotors and yaw control by differential collective pitch. Tires and wheels would be identical, with the larger model having them doubled in a bogey arrangement. Cargo and transport pods for the 120,000-lb model would be extended models of the smaller copter's pods.

The proposed two-bladed, semi-rigid rotor system is 115 ft in diameter, with a blade chord of six feet. Engine mounting is provided by a three-point attachment system from sling-type supports surrounding the engine. The supports are located between the flanges of the centrifugal compressor and the bearing support housing and at the rear end of the combustor housing in the plane of the attaching bolts for the exhaust duct combustor housing. The engine has a transonic, single-stage, axial compressor combined with a centrifugal compressor, a single-stage, axial-flow turbine, and an annular combustion chamber with a centrifugal fuel distributor. *Figure 2* also shows engine sfc vs power is for various tip speeds.—End

HEAVY LIFT helicopter powered by tip turbines in Hiller sketch. Note the short tail boom.

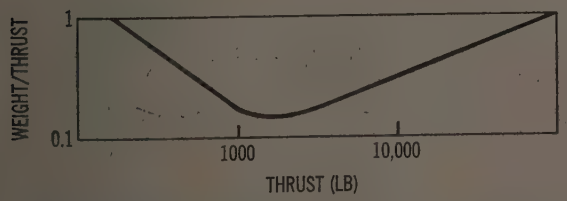
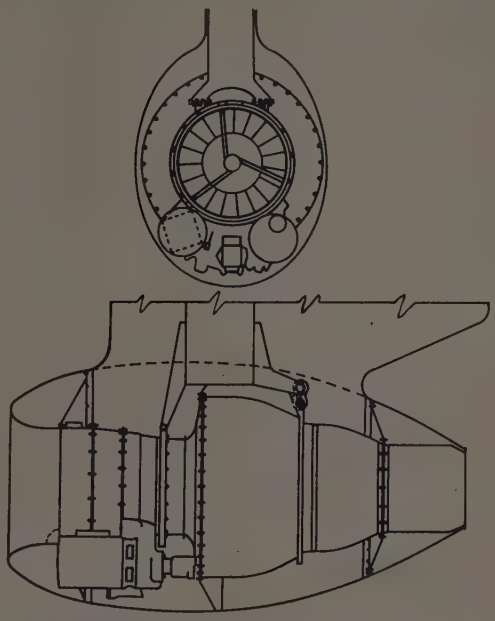
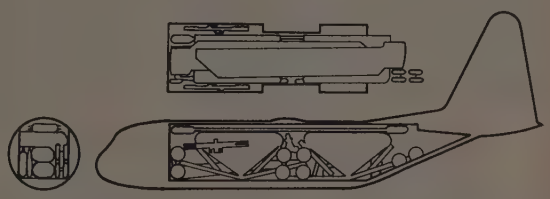


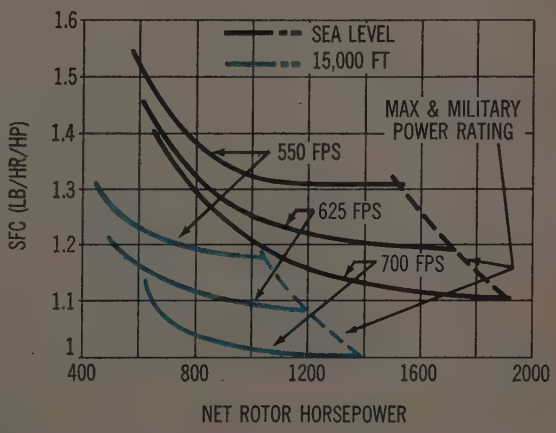
FIGURE 2: Minimum weight-thrust ratio for small turbojets is reached at about 2000 lb thrust (above). Multiples of the most efficient turbines should be used for large copters. Right: Estimated performance of tip-mounted turbojet in hovering on standard day at various rotor tip speeds. Curves reflect nacelle drag losses.



CONTINENTAL's J69-T-29 has been proposed as powerplant for Hiller rotor tip turbine design.



WITH POWERPLANT gear out of the fuselage, copters can be designed so they will fold for transportation in a C-130, as is shown by Hiller's Models 1089A (top) and 1089B.



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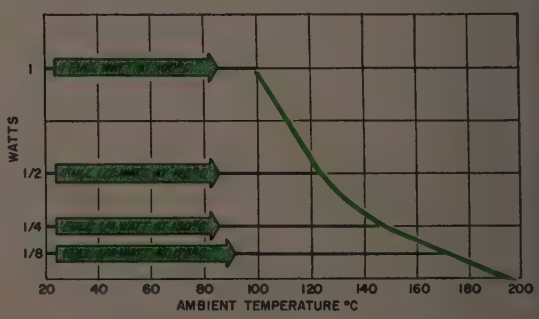

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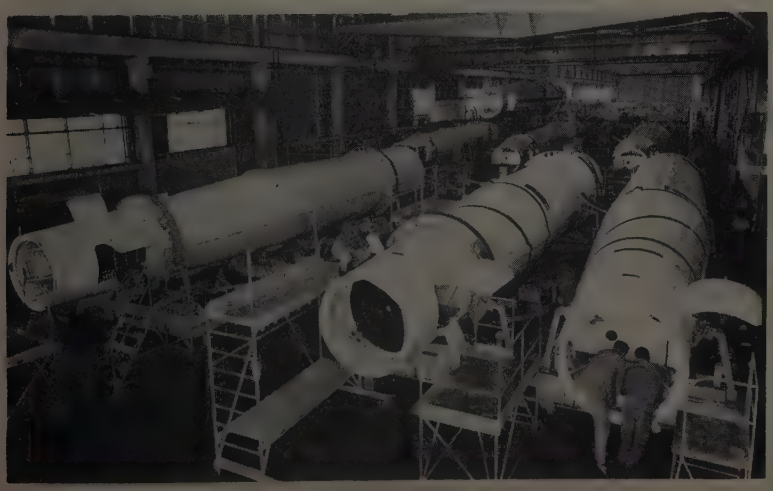
design progress

THOR intermediate ballistic range missile on launching stand with fuel and liquid oxygen lines connected. It has been, and will be, used as part of space payload launching vehicles, such as the Thor-Able configurations of the Pioneer shots. Below: Thor production line at Douglas' Santa Monica, Calif., plant. The three missiles in the foreground are at the guidance system installation station.



by Irwin Stambler
Associate Editor

Thor's structure is thin-gage aluminum

WITH weight saving even more important in missiles than in aircraft, Douglas' Thor IRBM design makes wide use of both chemical and mechanical milling. Most of the structure is aluminum. The single-stage missile has a gross weight of about 100,000 lb and a design range of 1500 nm. It is reportedly 65 ft in length, with a maximum diameter of eight feet. The main powerplant, made by Rocketdyne, uses RP-1 fuel and liquid oxygen (LOX). It has a thrust of 150,000/lb and is of tubular walled construction to permit recirculation of the fuel as coolant. Two small Rocketdyne vernier engines are used to provide precise corrections in yaw, pitch, and roll (see *S/A, "Small Engines Key to ICBM Accuracy," Oct. '58, p. 30*). Systems engineering for the Thor program was provided by Space Technology Labs; the all-inertial guidance system by *AC Spark Plug;* and the nose cone by GE-Philadelphia.

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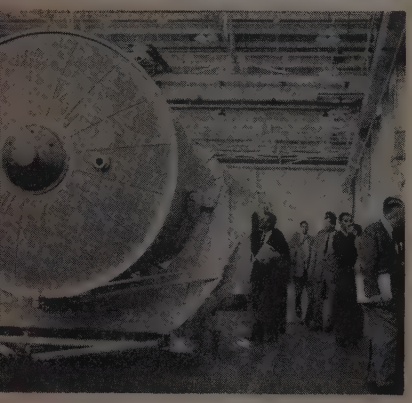


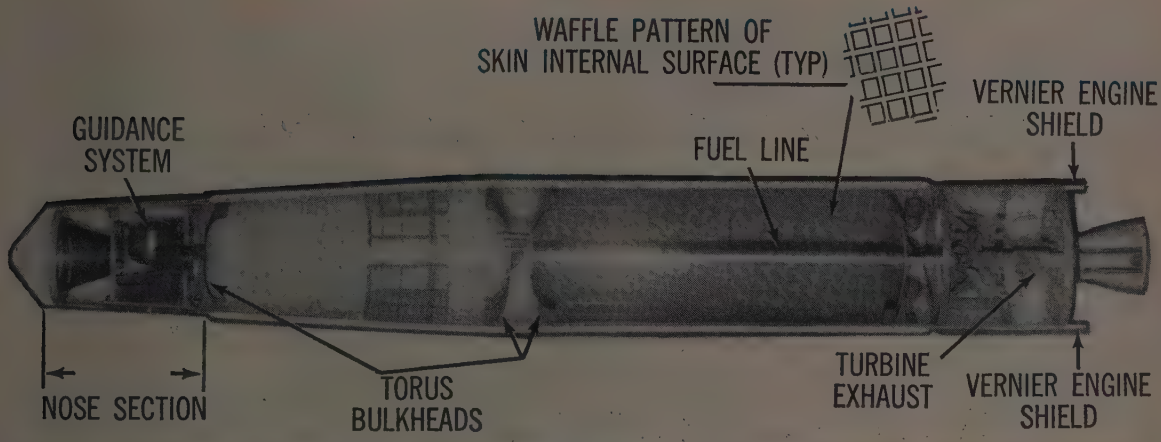
NOSE SECTION (top, excluding nose cone) is a conventional built-up structure with riveted frames and stringers, carries the electronic equipment. The aft (engine) section and the two connecting sections are also built-up designs. The tank area, however, is mostly of thin-wall, thin-gage aluminum construction, milled out internally in a waffle pattern for minimum weight. The Thor design makes wide use of conventional airframe fastening, such as riveting, in contrast to the Jupiter, whose structure is largely produced by seam and circumferential welding. Below: Torus bulkhead installed. These bulkheads form the ends of the fuel and LOX tanks.

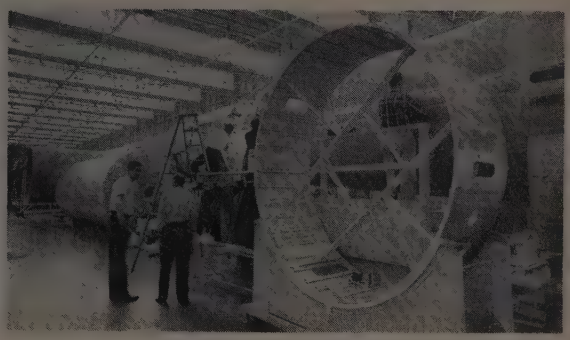
ENGINE END of Thor fuselage (top). Note vernier engine to the right of the main engine. Inner panels surrounding the engine screw into place (two of them are removed here). Bottom: Two connecting sections of the Thor fuselage. The cylinder in the foreground fits between the lower end of the LOX tank and the aft (engine) section. Note the hat stiffeners.

TUNNEL INSTALLATION along the missile's sides houses plumbing that can't go through the tanks. Clips (above) are used to hold the plumbing. After the plumbing lines, the wiring is installed, and the plastic inner section is screwed to the clips (above right). Then the large plastic outer cover is put into place and screwed into the ends of the clips (right).

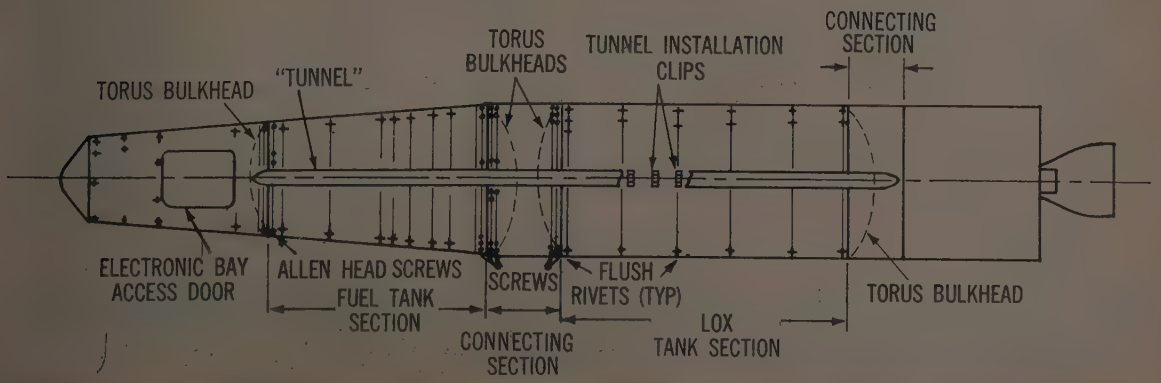
TORUS bulkhead is hand-reamed. Bulkhead in foreground shows chem-milled areas used to lighten structure.

design progress





WELDING and grinding operations (above left) on torus bulkhead tank fittings. Top: Cutaway shows how fuel line runs from the fuel tank to the engine through the center of the LOX tank. Below: Main Thor fuselage assemblies are shown in sketch (not to scale). Rivet and screw patterns are incomplete but give an idea of how fasteners are used. Above right: Connecting section between lower end of fuel tank and upper end of LOX tank.



DYNA-SOAR

Dyna-Soar (for dynamic soaring) is a joint project between the Air Force and the NASA, and is an attempt to solve the technical problems of manned flight in the sub-orbital regions. Advance knowledge on the project indicates how a boost-glide vehicle can operate from the outer fringes of the atmosphere where it can maneuver and be recovered undamaged. Studies show that by varying the original rocket boost, and thus the velocity, and with the control available to the pilot, the Dyna-Soar aircraft can circumnavigate the earth, followed by a normal and controlled landing. Boeing Airplane Company, one of the competing companies for the development contract for the complete boost-glide system, has delegated to RCA the responsibility for the development of important electronic components of Dyna-Soar.

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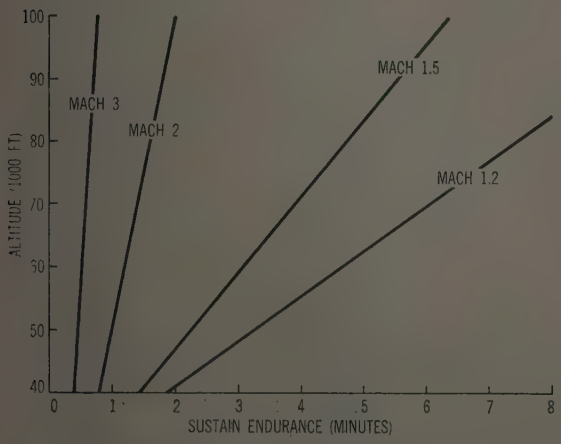


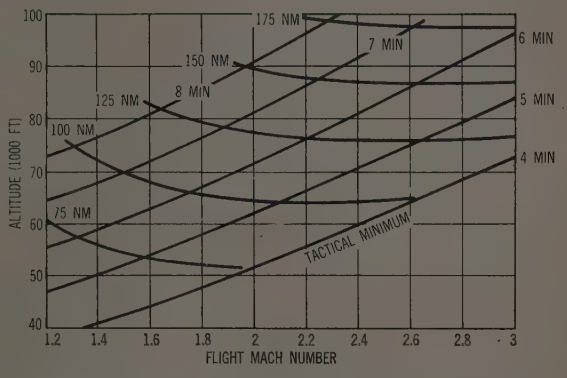


FIGURE 1: Drone breakeven endurance for equal ramjet and rocket system weights. For each Mach number curve, ramjets are heavier for the region to the left of the curve and rockets for the region to the right. Right: Maximum range and sustain endurance for rocket drones using storable liquid bipropellant if there is no boost impulse allowance, constant single-level thrust is used, maximum vehicle gross weight is 600 lb, and propulsion system weight is no more than 60 per cent of the vehicle gross weight.

Choosing engines for supersonic target drones

This is the first article in a two-part series on engines for supersonic target drones. The reason why good care must be taken to get just the right powerplant for a given drone mission is that powerplant cost may very well be the deciding factor in overall vehicle cost. This article gives details on the proper choice between ramjet and rocket engines; the second article next month will deal with rocket optimization.

by R. P. Reul, Branch Engineer, Propulsion Unit Analysis, Radioplane Div., Northrop Corp.*

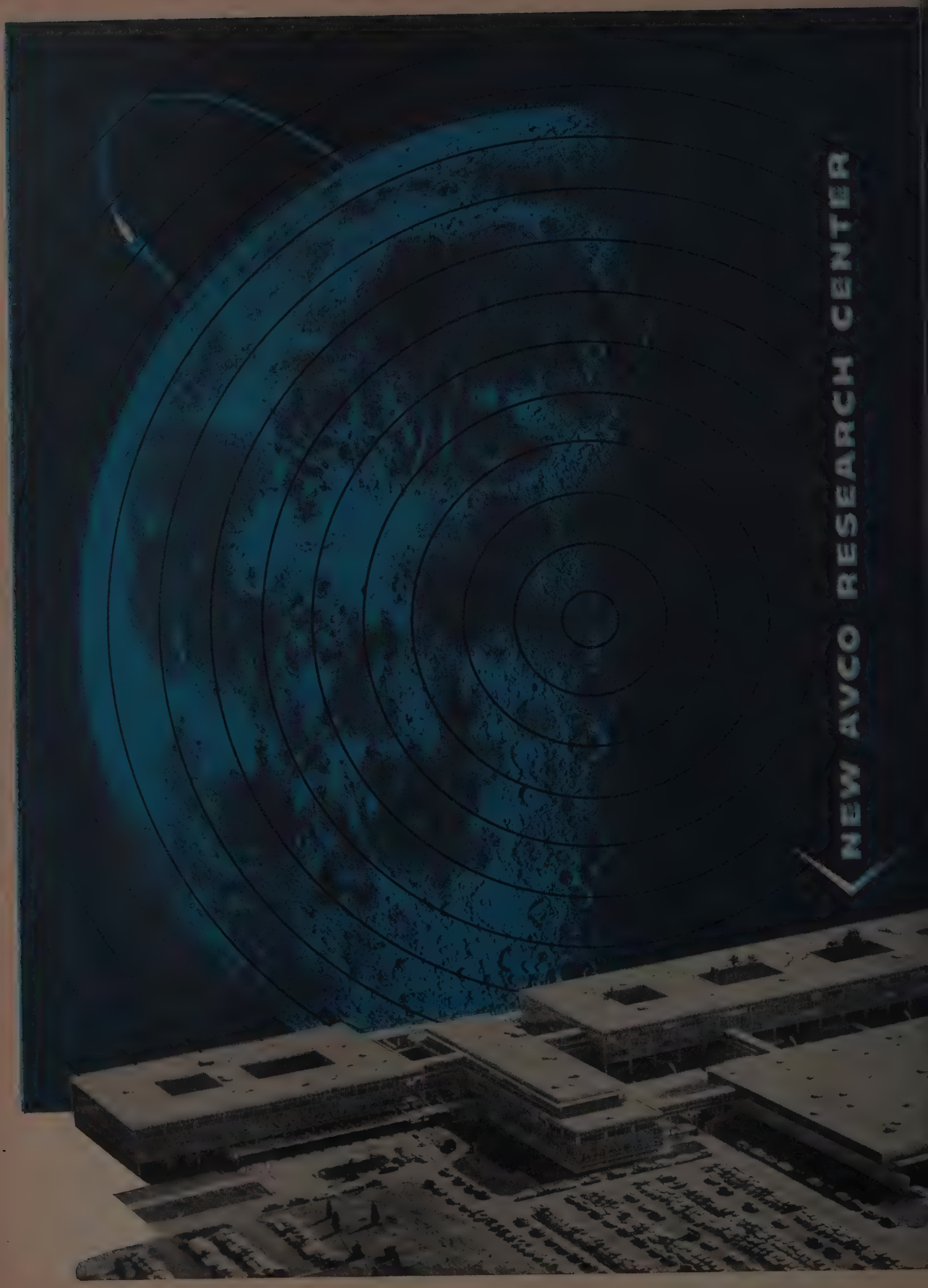
HIGH performance aerial targets, or drones, of course resemble missiles in their basic characteristic of being unmanned. Nevertheless, they are very different from missiles—especially in their powerplant needs. In a missile, the emphasis is on maximum performance for minimum weight.

The two engines best suited to today's supersonic target drones are the liquid fuel ramjet and the storable liquid bipropellant rocket. (Liquid monopropellants, though, are coming up fast.) For supersonic missions, the rocket is likely to prove superior under the following conditions:

- mission altitude of 40,000 ft or higher,
- range of 100-150 nm or less,

more on next page

* Radioplane Div., Northrop Corp., 8000 Woodley Ave., Van Nuys, California.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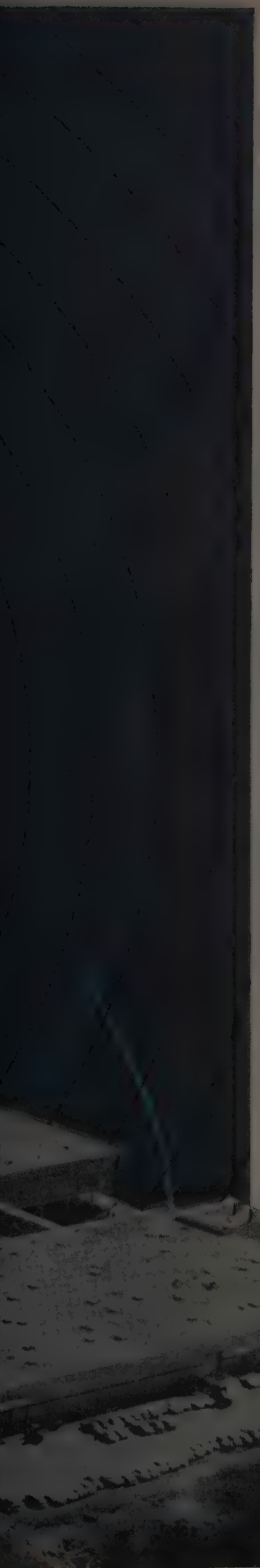

Space age research gets a new headquarters

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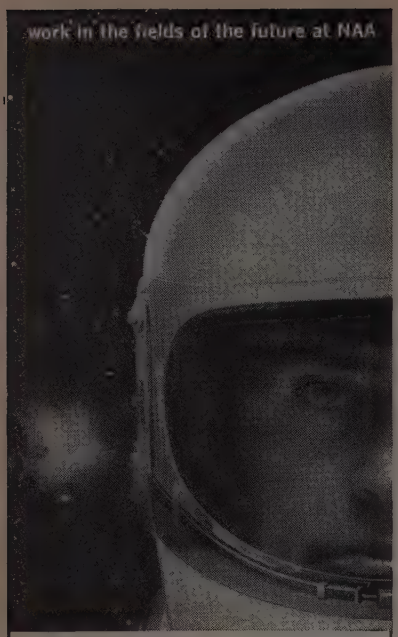

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- sustain endurance of eight minutes or less.
- adjustable thrust and endurance during both boost and sustain phases.

Endurance is a critical factor. At supersonic speeds, the cost of a two-pass design tends to exceed that of two one-pass targets. Accordingly, endurance is normally based on a single-pass mission.

At Mach 2, a liquid fuel ramjet is lighter than a rocket if the endurance is more than 1-2 minutes (*Fig. 1*). For an air-breathing engine, system weight increases only moderately with added fuel capacity.

But weight alone is not the answer. Development problems, propellant cost and availability, and thrust controllability must also be considered. The problem is to define the point of no return for different types of engines.

Rocket's upper limit can be fixed roughly

The upper limit for a rocket system is reached when the propellants and tankage to be carried lead you into a vicious circle of progressively increasing size, drag, and weight. Such a boundary is an elusive function of many complex, interdependent parameters. It can be fixed approximately if you make the following simplifying assumptions:

- Boost impulse requirements are disregarded.
- Sustain thrust is continuous and at a constant level.
- Maximum vehicle gross weight is 600 lb.
- Propulsion system weight is no more than 60 per cent of the vehicle gross weight.

A sustain endurance of four minutes is generally conceded to be the minimum for a tactical supersonic mission. For a rocket engine at high altitudes and Mach numbers, the maximum is about eight minutes (*Fig. 1*).

These are conservative figures. A change in the original assumptions can appreciably extend the limits. For example, with variable or intermittent thrust, range and endurance would increase appreciably.

Ramjets admittedly weigh less than rockets and use less fuel in sustained flight. But when a ramjet is used for acceleration and climb, the weight increase due to the boost fuel consumption just about cancels

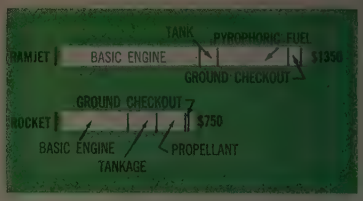

FIGURE 2: Propulsion system costs per flight for drones with a design life of three flights. Non-recurring costs of two ramjets or one rocket at $1200 each and of tankage are prorated for a single flight. Fuel requirements are 200 lb at two dollars each for the ramjet drone and 400 lb at $0.40 each for the rocket. Ground checkout cost is based on nine dollars per hour.

the ramjet's weight advantage. If the ramjet is to take care of climb and acceleration as well as level flight, the mechanics of regulating the fuel-air ratio become quite complex.

Experience shows that today the production cost of any aerial target runs to about 3-6 times the cost of its propulsion system. Where expensive propellants are involved, operational costs also become significant.

Production costs of small drone rockets using storable liquid propellants range from $500 to $2500, depending on the number of thrust chambers and the control complexity. Pyrophoric-fuel ramjets are in the same price range. The rocket, however, is inherently reusable, while the ramjet is not.

Tankage is usually an integral part of the airframe. It is somewhat more expensive for the rocket system which needs higher pressures and greater propellant capacity.

Present rocket propellants cost $0.13-0.80 per pound, compared with $5-20 per pound for pyrophoric ramjet fuels (which, however, should drop to $1-2.50 per pound when produced in quantity). As a result, even though the rocket uses 1.5-2.5 times more fuel than the ramjet, the total fuel cost is a lot lower. Preflight checkout is also much less time-consuming with the storable liquid rocket, so operational costs are lower, too (*Fig. 2*). R&D costs through preflight rating tests are $1.50-2 for the ramjet and $0.50-1 for the rocket.

Flexibility, logistics, and opera-

more on page 73

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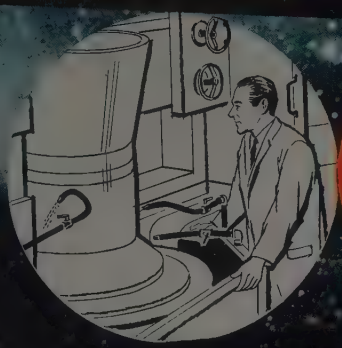

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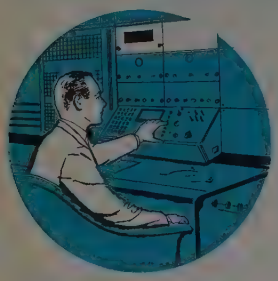

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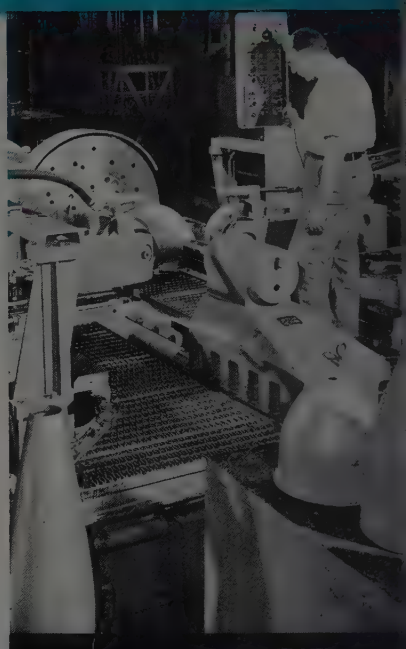
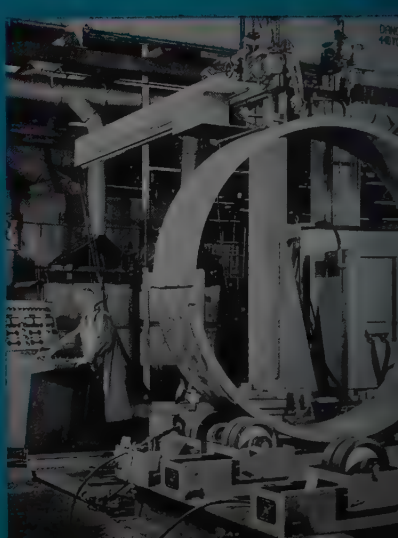
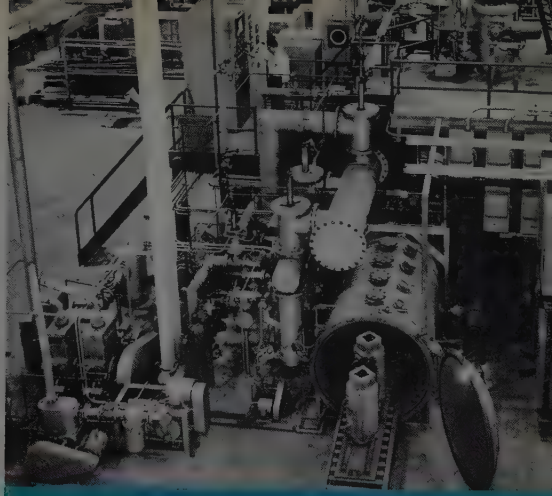
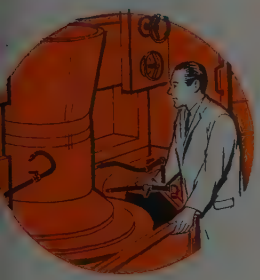


"Chipless machining" of special-alloy nose cones for Bullpup air-to-surface missiles by hydrospinning, or roll-forming, at a high production rate in the TAPCO Group facilities







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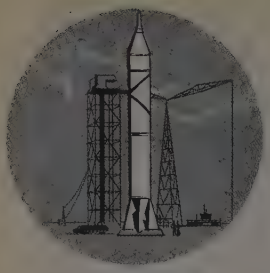

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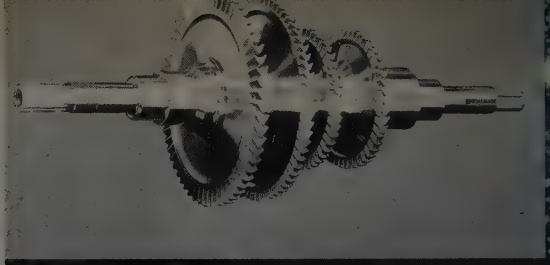
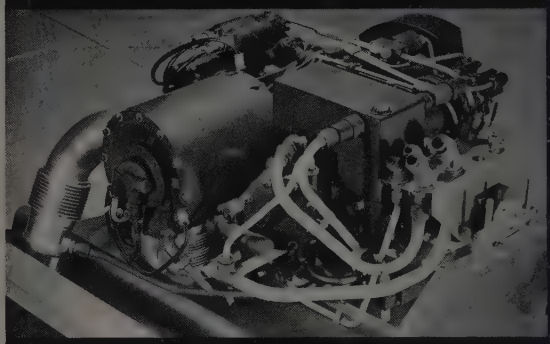
Experience in the TAPCO Group also includes nuclear-reactor engineering, production of high-speed rotating machines to meet all temperature problems, and development and production of self-contained auxiliary power units of various sizes, duty-requirements, and configurations.

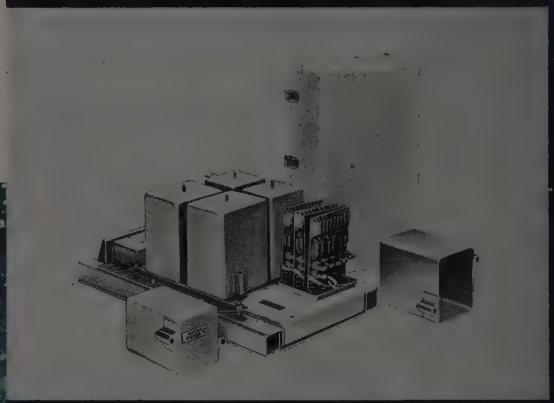
Let a TAPCO Group sales engineer explain how we can work with you to develop and deliver on-schedule any program or part of a program to meet your specifications.



Precision one-piece, four-stage turbine rotor for high-speed operation in auxiliary power units. Designed and manufactured at TAPCO.



APU developed and built by the TAPCO Group for use with exotic fuels. Testing was done under simulated operating conditions at TAPCO's 1100-acre Roanoke Test Facility.



Electronics equipment produced by the TAPCO Group includes wave guide switches, speed-sensing devices, microwave antennas and filters, computing systems, electro-pneumatic controls.

The TAPCO Group designed and supplied the entire roof structure, forward and aft doors, and actuating system for the Bomarc Model II missile shelters at the first operational sites at Eglin and Suffolk County Air Force bases. TAPCO also provided full field supervision to direct assembly and demonstrate functional operation.

TRW

TAPCO GROUP

Thompson Ramo Wooldridge Inc.

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DESIGNERS AND MANUFACTURERS OF SYSTEMS, SUBSYSTEMS AND COMPONENTS FOR THE AIRCRAFT, MISSILE, ORDNANCE, ELECTRONIC, AND NUCLEAR INDUSTRIES

tional simplicity may also have a profound effect on operational costs. Drone propulsion systems are "economical" only if flexible enough to permit:

- changes in the basic mission between preliminary design and operational use of the hardware,
- changes in the drone's aerodynamic and structural characteristics,
- state-of-the-art advances in launching techniques,
- extension of vehicle capabilities to handle additional or alternate missions.

The propulsion system should be capable of growth in thrust with only minor modifications. Here solid rockets are at a disadvantage, since their thrust and total impulse levels are essentially fixed for a specific configuration. Storable bipropellant liquid rockets (with a nitrogen-pressure feed system), though, are quite adaptable. Substantial increases in thrust are pos-

more on next page

"FAR-SIGHTED" MIRROTEL LENSES CAN

Wollensak Mirrotel Lenses (20", 40" and 80") extend the capabilities of high speed motion picture photography in tracking missiles and in radar boresight applications. They deliver images of excellent resolution and contrast.

ADVANTAGES • Because of mirror optics (the light path is "folded" three times within the system) the lenses are short and lightweight . . . are free from chromatic aberration, coma, astigmatism, distortion . . . are most stable under extreme environmental conditions. Invar rod mounting permits high boresighting accuracy.

CAMERAS • Mirrotel lenses are extensively used with a wide variety of cameras, such as FASTAX, FASTAIR, Flight Research IV-C, Automax, Mitchell (16mm, 35mm), Cameraflex, Eyemo and TV cameras.

SPECIAL FEATURES • Mirrotel Lenses can be supplied with reticle printers, fiducial markers, continuous focusing, counters, reflex finders, radiation shields, custom mounting bases for lens and camera (illustrated), neutral density and color filters.

If you need extra long focus lenses of unusual characteristics, **WRITE** Dept. FXL for Mirrotel catalog M-1 and prices. Inquiries invited.

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BEHIND THE SCENES IN THE CONQUEST OF SPACE
S-N
HIGH SPEED INCREASER UNITS
Illustrated is S-N Model 4092-1 high power Speed Increaser rated 1,700 HP at 8,000 RPM. Used for dynamometer testing of gas turbine engines.

Vital to the wondrous advancement of our rockets, missiles, and jets are the grueling tests and checkout of their components on high speed test stands that simulate actual operating conditions during flight. Today, major test installations are equipped with S-N High Speed Gear Increaser Units. Most jets have components checked on S-N equipped high speed test stands.

Whatever your requirements for high speed testing, S-N has a standard unit or will design and build, to your specifications, units from 2 to 2,000 HP to operate at speeds from 80 to 80,000 RPM. They are the product of transmission engineers with over a half century of experience and are built to highest standards of quality. For complete information, write The Snow-Nabstedt Gear Corporation, Hamden, Conn.

SNOW-NABSTEDT

Industrial Division

Transmission Engineers FOR OVER HALF A CENTURY

Write in No. 6 on Reader Service Card

sible by increasing the chamber pressure and changing the propellant injectors.

There is at least one liquid rocket thrust chamber design with interchangeable nozzle inserts of different area ratios, which further increase the range of potential performance. Excellent growth potential can be achieved if you start out the design with a low chamber pressure and a tankage that can be easily modified for greater storage capacity.

Ramjets are not so well suited to such performance uprating, since the thrust level is largely determined by the basic engine diameter. More sophisticated fuel controls, inlets, and nozzles can improve performance—at the expense of reliability and system cost. Sharp penalties in sfc may be incurred if the fuel flow is increased (to boost thrust) without appropriate changes in engine geometry.

Logistics are important in the selection of fuel or propellant. Field filling of hazardous liquids is impractical under most operational conditions, so it is safe to assume that pre-packaged propellants will be used.

Hypergolic storable propellants are being shipped by common carrier as "Class 1—Fire Hazard Only" under ICC regulations — even when several share the same integral container. The same propellants can be stored and used without difficulty or danger over the full military temperature range.

Pyrophoric fuels pose fire hazard

There is very little service experience on the handling of the pyrophoric ramjet fuels needed for high altitude missions. Shipping and handling regulations for flight-type containers have not yet been formulated, but there is no denying that a fire hazard does exist.

Some of the pyrophoric fuels also react violently with water, so that special fire-fighting techniques must be developed. However, storage over the full temperature range does not appear to be a problem.—End

PRODUCTABILITY

New, highly-advanced techniques developed by Houston Fearless make possible substantial savings in time and cost in precision machining of extremely hard, high-temperature alloys such as Discaloy, Hastaloy, Udimet 500, René 41, Waspaloy, Inconnel X and 700. Research and development work invited. Submit drawings for help on your specific problem.

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Portable Pyrometer Indicator Does Many Jobs

MINIMITE®

Null Balance, Potentiometer Type

The "MiniMite" Portable Potentiometer Indicator gives you laboratory accuracy in a rugged, versatile instrument. Use it conveniently for a wide range of temperature measurement, calibration and test purposes. Its dimensions are only 4" x 5" x 6"—weight is under 4 lbs. Accuracy is ¼ of 1% of scale range.

Temperature Measurement For direct temperature measurement, connect the "MiniMite" to a thermocouple. It's ideal for laboratory work, emergency operation or substitution for instruments under repair...also for many types of research and test work.

Calibration Use the "MiniMite" with equal facility for calibrating thermocouples, or both potentiometer and millivoltmeter-type instruments.

Scale Range Individual ranges on the "MiniMite's" double-range scale are almost 24" long. Choose from 49 different range combinations to cover temperatures from −300°F. to +3200°F. for all standard thermocouples, and millivolts from −6.2 to +62.

Write For Bulletin 64-A

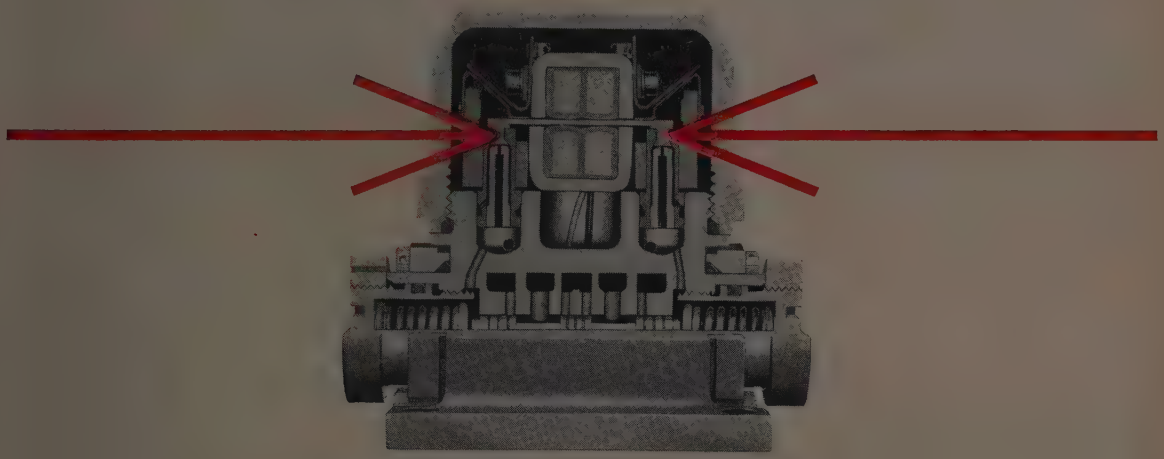
Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

In Canada:
THERMO ELECTRIC (Canada) LTD.
Brampton, Ont.

Write in No. 8 on Reader Service Card at start of Product Preview Section

VOLUME PRODUCTION

HYDRAULIC SERVO VALVES WITH HIGH RESISTANCE TO CONTAMINATION



This is the Bendix-Pacific Electro-Hydraulic Servo Valve with the **shrouded nozzles.** It offers the advantages of both a dry coil and a wet coil valve by isolating the torque motor from circulating flow. There is no sacrifice in performance normally associated with dry coil sealing devices.

The Bendix-Pacific **shrouded nozzles** are parallel to each other. This provides a torque motor with two air gaps, doubling available torque. As the armature does not operate about a fixed point three advantages result: (1) Larger flow passages that are less susceptible to contaminants. (2) Higher response is achieved by faster exhausting of spool and pressure chambers and (3) Nozzle back pressure is sustained with reduced supply pressure thereby maintaining stiffness and null stability.

These Bendix-Pacific Servo Valves are in volume production. Application engineers are available to discuss system problems and adaptation of these valves to your specific needs.

Bendix-Pacific
DIVISION OF BENDIX AVIATION CORPORATION

11630 SHERMAN WAY, NORTH HOLLYWOOD, CALIFORNIA

NEW YORK CITY • DALLAS, TEXAS • DAYTON, OHIO • WASHINGTON, D.C. • SEATTLE, WASHINGTON

Write in No. 9 on Reader Service Card at start of Product Preview Section

New from Honeywell: a high-performance miniature gyro with input freedom of ±60 degrees

Advanced design of the Wide-Angle MIG allows you to program missile flight while cutting size and weight of missile guidance system by more than 50 per cent.

HONEYWELL's leadership in gyro design is proved again. The new Wide-Angle MIG is a miniature integrating gyro with such a wide range of input angular freedom that it can be moved about its input axis up to ± 60 degrees without loss of space orientation.

At the same time this new gyro retains all the accuracy and extremely high performance characteristics of Honeywell's famous MIG family.

A floated gyro, the Wide-Angle MIG employs a damping technique that represents a distinct advance in the state of the art. It's the perfection of this technique that makes possible a gyro combining great input freedom with high accuracy.

Honeywell's Wide-Angle MIG offers advantages across many applications.

It is the most accurate miniature floated gyro available for radar systems that warn of distant ballistic missiles. Locked into the radar, it is capable of measuring a rate of movement as low as 10^{-6} radians per second—far superior to the rate gyros which are normally used in such applications.

In fact, the new gyro provides unusual benefits in any application that requires small size and weight, high accuracy and great input freedom. It is designed for both analog and digital rebalance systems and has other features which include increased torquing rates (to 80,000° per hour) and tolerance of ambient temperatures to 500°.

For complete information on Honeywell's new Wide-Angle Miniature Integrating Gyros, call or write Honeywell Aero, 2600 Ridgway Road, Minneapolis 13, Minnesota.

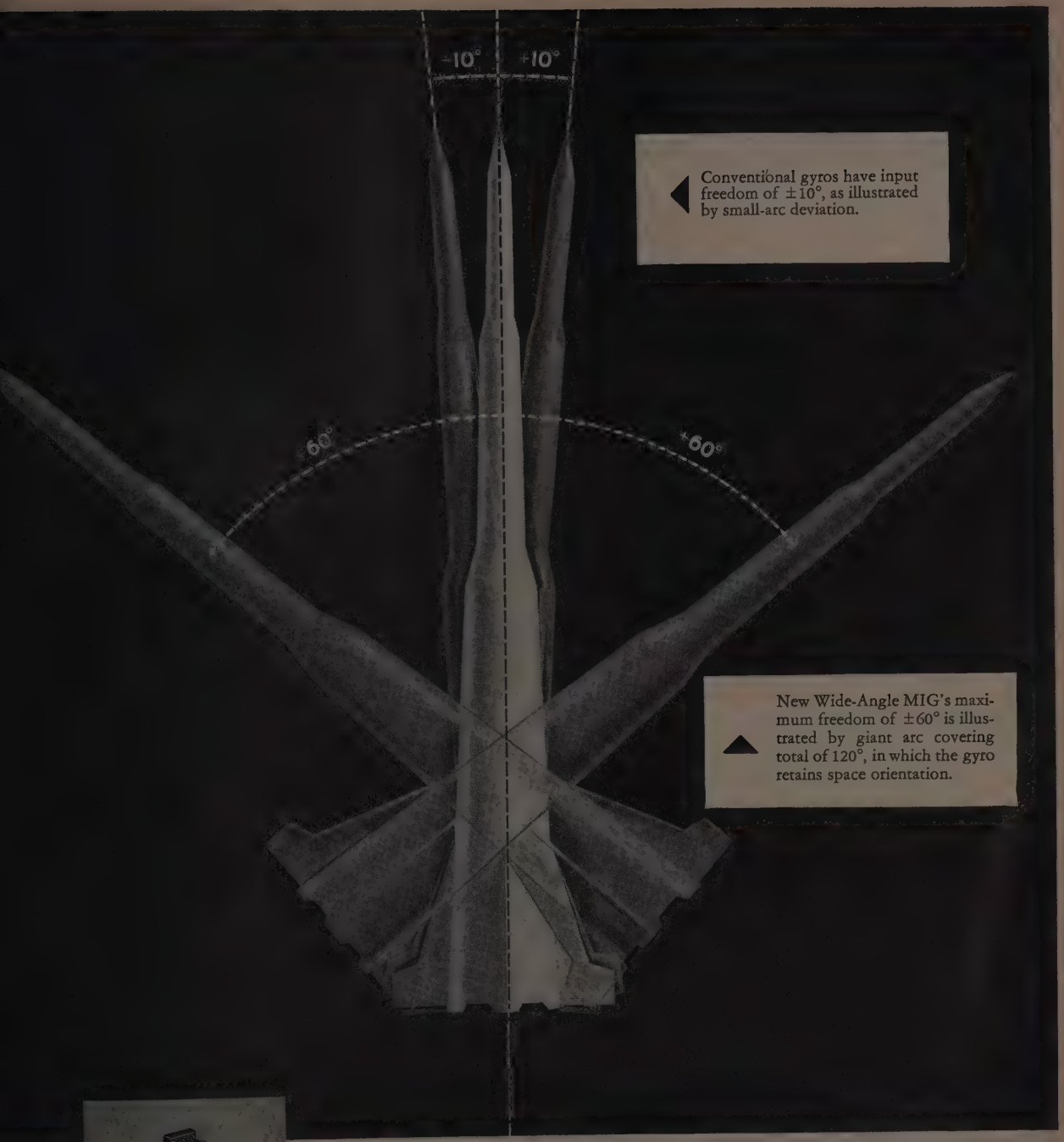
WIDE-ANGLE MIGS BY HONEYWELL

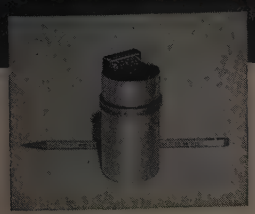
GG107 gyro for digital systems

GG90 gyro offers 60° input freedom

GG87 gyro has extremely low drift rate (exact rate classified)

GG83 gyro operates in ambient temperatures of 500°F.


-10°
+10°
Conventional gyros have input freedom of ±10°, as illustrated by small-arc deviation.
60°
60°
New Wide-Angle MIG's maximum freedom of ±60° is illustrated by giant arc covering total of 120°, in which the gyro retains space orientation.



Wide-Angle MIG illustrated occupies less than eight cubic inches, weighs less than one pound. It's part of Honeywell's complete line of 24 floated and two-axis gyros for all high-performance aircraft and missile requirements.

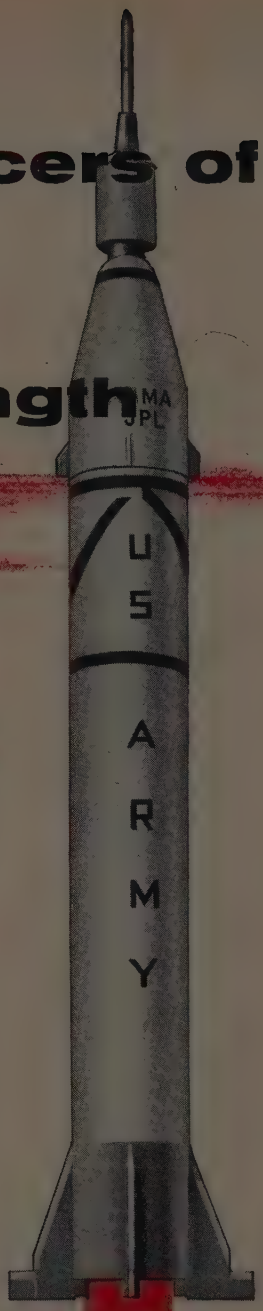
Honeywell

Military Products Group

Exclusive Producers of

High Strength

98% H_2O_2



Only Becco can supply you 98% Hydrogen Peroxide in commercial quantities—in tank cars or drums. For use both as a monopropellant and an oxidant, superpure 98% H_2O_2 is a stable liquid over a wide range of temperatures (B.P.: 299.2°F.; F.P.: 27.5°F.). Its high density (Sp. Grav.: 1.44) reduces space requirements per unit weight. Its ease of catalytic and thermal decomposition makes for simple and reliable systems.

Yet, these are only a few of the advantages of 98% H_2O_2 in propulsion. Becco, as the pioneer in the field, is especially well equipped to provide you with complete information on all phases of the use and handling of Concentrated Hydrogen Peroxide. Write today for free samples and our newest Technical Bulletin (No. 93), "Anhydrous Hydrogen Peroxide as a Propellant". Address: Dept. SA-25.

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Write in No. 10 on Reader Service Card at start of Product Preview Section

Design tips for cryogenic storage vessels

by G. F. Sulfrian, President, Hofman Laboratories, Inc.*

Many of today's low temperature storage vessels, this article points out, don't give anywhere near the performance they could give if they had been designed to tighter specs backed up by good quality control.

TIGHT specs are the main requirement for efficient storage and transport of liquefied gases. Two well-designed vessels built to the same "loose" spec may differ appreciably in performance and efficiency.

One might hold its effective vacuum for a year or more before servicing; the other might need attention as often as once a week. Depending on design detail, evaporation losses after normal periods of inactivity may be excessive for one design and practically negligible for the other. And again one vessel might operate without interruption while being filled, while the other must be shut down.

A vessel can be properly designed only after a very careful and detailed analysis of its expected operation. Each operating requirement should be satisfied in order of importance, so that the design criteria can be developed progressively. The operating requirements can be conveniently analyzed in terms of capacity, working pressure, allowable evaporation loss, and operational procedures.

Basically, the vessel is sized to meet existing requirements as governed by flow rate and frequency

* Hofman Laboratories Inc., Hillside, N. J.

more on next page

SIZE of liquefied-gas storage vessel is determined by operational use. Fifteen-gallon vessel (left) is for field supply and in in-plant transportation of LOX. Large unit is a 4000-gal. trailer transport for LOX and nitrogen.

8298-SR

An important advantage in missile development

The critical environmental specifications of current air weapons systems are being met by dependable Silicone rubber parts. Only Silicone rubbers retain their rubber-like characteristics under severe operating conditions . . . provide temperature resistance ranging from −160° to +600° F. Stalwart's modern Silicone Department is now producing accurate rubber parts for jet engines, instruments and other electronic equipment. Extruded and calendered *Silicone sponge* parts are produced for aircraft gasket and seal applications. Write us today about your special rubber parts problem.

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of use. But it might well be made oversize to anticipate increased demands at some future date.

The capacity of available transport vessels, and the expected frequency of deliveries also affect the size of a storage vessel. The less reliable the supply service, the greater must be the contingency factor added to daily consumption figures in determining the "working capacity" of the vessel.

Much the same reasoning applies to transport vessels. The sizes, locations, and servicing schedules of the storage vessels to be filled all influence the working capacity of the transport.

Final working capacity is often a compromise

The final working capacity often represents an economic balance between actual consumption figures and the critical supply factors. However, calculating the "design" or total rated, capacity of the vessel involves still more factors. It is good practice, for example, always to maintain some liquid in continuously operating vessels, to take care of unexpected contingencies and to assure top operating efficiency.

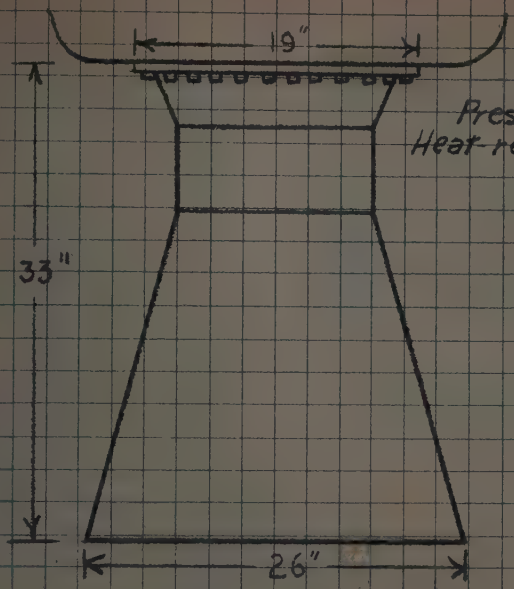
Residual liquid, as the minimum level reservoir is known, prevents the inner tank from "breathing," or taking in warm air from the outside. The warm air coming into contact with the cool walls condenses into moisture. If repeated often enough, the warming and cooling cycle creates ice particles that will destroy valve seats.

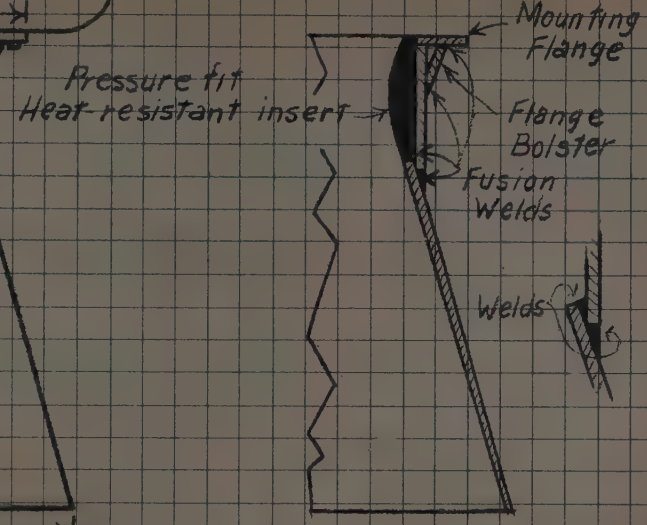
Residual liquid also helps control the size of the "vapor area" above the liquid level. As the liquid level drops, the vapor area increases and the pressure within the vessel decreases. This, in turn, can reduce the discharge rate.

A certain amount of vapor build-up is needed to establish a basic minimum "working pressure" within the vessel to provide transfer or discharge pressure. This minimum is one of the factors governing the size of the vapor area. However, the frequency of discharge operations must also be considered. Care must be taken that the pressure build-up is relieved often enough to avoid excessive pressures that would pop the escape valve and blow vapor into the atmosphere.

A week-end is often used as the

more on page 82





Four Welded Rings = One Nozzle

Nozzle cone for 100,000 lb. thrust is a WELDED RING ASSEMBLY with refractory insert

A booster rocket delivers a 100,000 lb. thrust. The nozzle cone—which takes this tremendous punch—is a welded assembly. Amweld engineers, working with a prime contractor, developed a method that simplified the fabrication of this vital part and reduced the cost.

The conical section is rough formed from a single piece of plate, welded, and circular formed. Other sections are torch cut from plate, formed, and welded together to form the completed assembly. After heat treating and machining, a graphite insert is fitted inside the nozzle cylinder.

Delivered at a considerable savings in fabricating and material costs, this Amweld welded assembly meets all requirements for this critical application.

This typical Amweld fabrication by welding can save you time and money. If you would like to know more about Amweld's prototype and production facilities, phone or write.

GET THE FACTS ABOUT AMERICAN WELDING

Complete information. Facilities brochure, Precision Assemblies Catalog, and booklet on "How Flash Butt-Welded Rings are Made."

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AMERICAN WELDING

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An aggressive tool development program that has produced simple, sturdy, lighter weight installation tools that will produce uniformly "skilled" quality fastenings in the hands of "unskilled" operators, with less fatigue.

A thoroughly experienced staff of fastening engineers who will carefully analyze your problem and give you accurate advice for its solution.

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INSTRUMENT and control section of a 300-gal LOX and nitrogen tank. Design features bottom fill and discharge lines, liquid level gage, vacuum valve and fillers, thermocouple quick pressure build-up system, and quick-disconnect couplings on liquid lines.

longest build-up period for computing vapor area requirements. Where vapor loss is a serious consideration, closed-cycle techniques can be used to reclaim the exhaust.

Working pressures are kept to a minimum where intermediate pumps are used to provide the delivered pressure and flow. Generally, 56 psig or less will do, since the pressure merely has to get the liquid into the pump line.

Internal working pressures of 250 psig or more may be needed when the vessel discharges directly to the end use point. The exact pressure depends on how the supply is used and the state in which the liquid is to be delivered.

The working pressure has a profound influence on design and initial cost. Obviously, an increase in working pressures usually means greater wall thicknesses, more weight, changes in suspension system design, etc. When the pressure is to go much over 250 psi, chances are it will pay to go to a lower-pressure vessel and a liquid pump.

The rate at which liquid in the vessel is unintentionally converted to vapor is known as the evaporation rate. It is normally expressed in cubic feet of vapor per hour or as a percentage of the working

more on page 84

...NEWS IS HAPPENING AT NORTHROP

Demonstrating the platform of LINS – new, Lightweight Inertial Navigation System – is Dr. William F. Ballhaus, Vice President and General Manager of Nortronics.

NORTRONICS REVEALS LINS... COMPLETE PRECISION INERTIAL NAVIGATION SYSTEM!

A recent demonstration at Nortronics' Guidance Symposium revealed the most advanced precision inertial guidance system ever assembled. LINS–Lightweight Inertial Navigation System – includes platform, platform electronics, environmental control and computer. Total system weight: slightly in excess of 100 pounds. Equipment volume: less than three cubic feet.

Actual working hardware, LINS is a complete, precision system for automatic navigation applications to advanced aircraft, drones, missiles, and space vehicles. It is ready now – the latest result of Nortronics' more than twelve years of creative research and production in the field of automatic guidance and navigation systems.

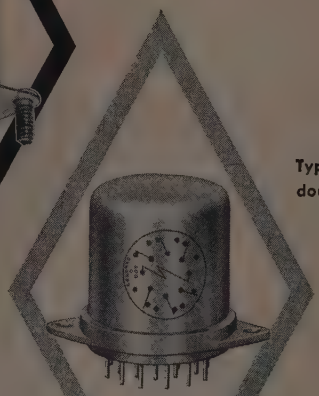
If you have the need to know more–contact Nortronics today, regarding LINS for your own system requirement. Nortronics' experience offers unique and proven capabilities in tailoring the design, development and production of complete and integrated guidance systems to your requirements.

NORTRONICS

HAWTHORNE, CALIFORNIA

A Division of Northrop Corporation

Type FC-4 4-pole double-throw.



Type FC-6 6-pole double-throw.

These Improved MISSILE RELAYS

withstand 30G vibration at 2,000 cycles

... up to 60G shock without contact opening

... and 2,000 ft.–lbs. shock without contact transfer

Backed by more than ten years of intensive development and refinement, these rugged, precision-built Struthers-Dunn FC relays have the high reliability required for missile uses. The outstanding characteristics indicated above typify performance that meets or exceeds the operational and environmental requirements of MIL-R-5757C and MIL-R-25018. Thanks to simplified design, S-D FC Relays, are priced materially lower than other types frequently used to meet these exacting specifications.

MAKERS OF THE WORLD'S LARGEST ASSORTMENT OF RELAY TYPES

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giving full details and electrical and mechanical specifications. Ask for FC Relay Bulletin.

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Pitman, N. J.

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Write in No. 14 on Reader Service Card at start of Product Preview Section

capacity that evaporate ss is hours. s of

The rate of evaporatior nnu- determined by the effective and the thermal insulation in the or- lar space between the inner al outer tanks of a vessel. This al mal insulation is affected by sla- design features, notably: by er vacuum, vacuum tightness, in tion, powder used, and the nur- of inner-tank heat paths.

Small lab containers can be signed to hold a so-called ha vacuum of 10^{-5} microns or bett But storage and transport vesse for liquefied gases normally ar evacuated to about 10 microns o less, considered a "medium" vac- uum. Once the vacuum deterio- rates to 250-300 microns, the ves- sel loses most of its insulating effectiveness.

Permanent vacuum pump frequently helps

Many vessels now in use lose enough vacuum through leaks or outgassing so that the annular space must be re-evacuated as often as every five days. Frequently the solution is to permanently install a vacuum pump on the vessel. (At a cost considerably less than that of a pump, the vessel could have been designed at the outset to stand empty for 6-12 months without vacuum deterioration.)

Most vessels are fabricated with a cold vacuum of about 10-50 microns. If the specs permit a leak rate of a 24-micron rise over 24 hours (as they often do), the minimum acceptable vacuum effectiveness can be reached in less than 10 days. At that time, the vessel must be serviced to restore the vacuum.

Recently, it has been more common to specify a permissible leak rate of an 0.5-micron rise per hour. This keeps the vessel operable for a month between servicing. With rigid quality control and accurate test procedures, the leak rate can actually be held to an 0.02-micron rise per hour. At that rate, the vessel could operate continuously for more than a year without servicing.

One of the most controversial issues in the design of a vessel is the advisability of installing a top fill line. Although a single line is often used for filling and draining, good design calls for separate lines.

With a top fill line, the vessel

more on page 86

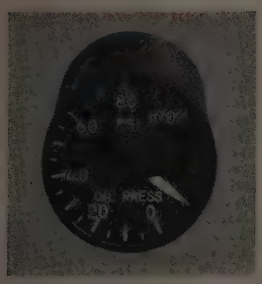
new

THOMAS A.

EDISON

oil pressure indicating system withstands vibration to 2000 cps at 20g's

Transmitter is mounted directly on engine and connected to panel indicator and power source by 3 unshielded copper wires.



Indicator is hermetically sealed — requires less than 0.6 watts to operate. When power is off pointer will move off-scale below zero. Available in 1½" and 2" (shown above) sizes. Two-inch size may be integrally lighted.

Designed for use on all new jet engines, the new Edison oil pressure indicating system consists of two components — a transmitter and panel indicator. Because the Model 318 transmitter can withstand vibration to 2000 cps, it may be mounted directly on these engines without shock mountings. As a result, it offers greater reliability, accuracy and speed of response.

Ordinary transmitters must be mounted off the engine and then connected by hose or tubing to engine pressure source. In sub-zero temperatures oil in hose can thicken and false or delayed pressure indications may result.

The new Model 318 transmitter is 50% smaller and 50% lighter (1.0 lb.) than the model 218 developed by Edison in 1956. It will meet requirements of new specification MIL-T-26638.

Its simplified electro-mechanical design makes installation and maintenance easy. Frictionless transmitter has only one moving part and maintains its accuracy in temperatures to 232 C.

For additional information write for publication 3049.

Thomas A. Edison Industries
INSTRUMENT DIVISION
48 LAKESIDE AVENUE, WEST ORANGE, N. J.

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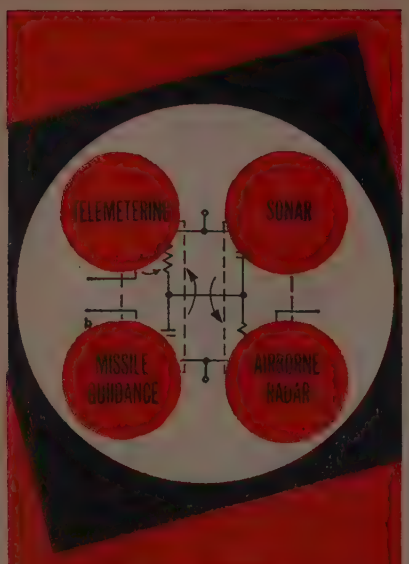
can be filled while liquid is being drawn off so that supply services are not curtailed. Another distinct advantage is that liquid admitted through the top fill line passes through a spray feeder to the vapor area of the inner tank. The fresh liquid chills and condenses vapor that might otherwise be forced out through the safety valve as the liquid level rises.

Rates of fill and discharge must also meet operational requirements. Here again, though, an economic balance must be established between desired flow rates and cost. To increase the discharge rate, for example, it is necessary to increase the working pressure or the line size or both. In any case, the cost is increased. When you increase the line size, you also risk a loss in thermal efficiency because of the larger heat paths provided by the larger valves, pipes, and couplings.—End



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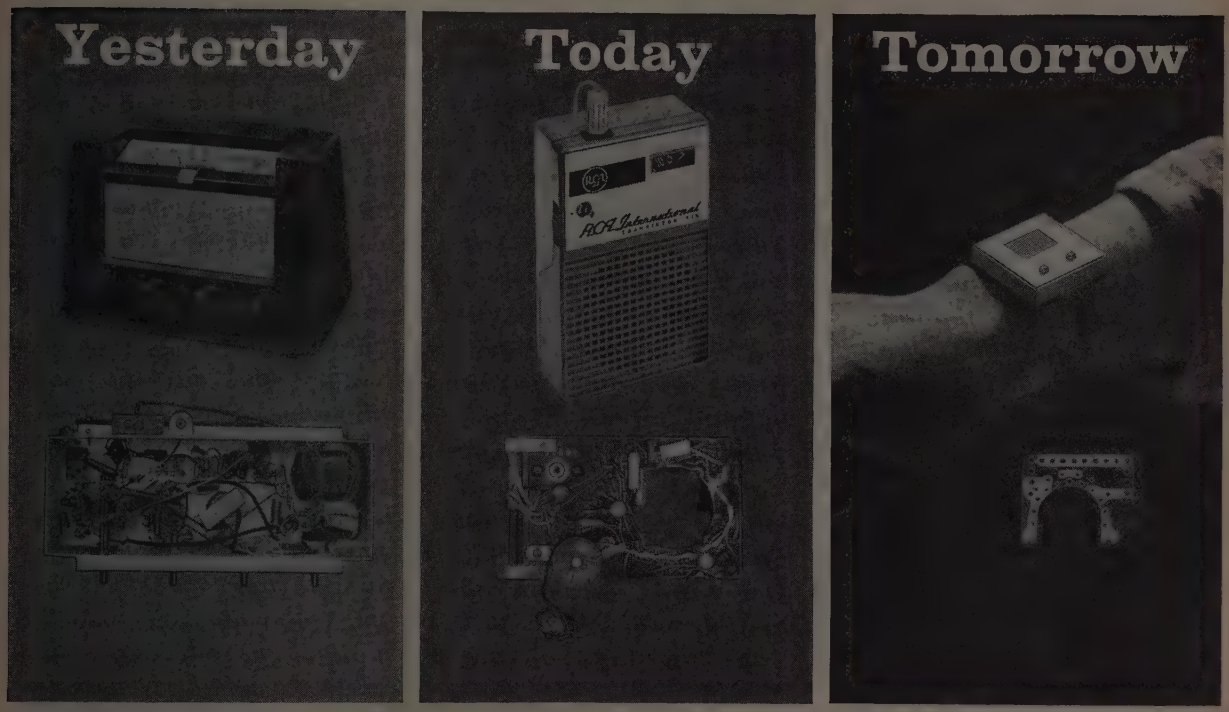
Miniaturization of electronic components highlights need for Synthane plastic laminates



The tremendous increase in miniaturized electronic components emphasizes a need for the combined properties of Synthane laminated plastics.

Miniaturization, as you know, reduces the insulated path between terminals or conductors, placing a premium upon the insulation resistance of the laminate.

Printed Circuitry Adds to Problem

Printed circuitry, the development that made so many miniature circuits possible, also magnifies the insulation resistance problem because there is a temptation to save space by shortening the distance between conductors. And often the insulation resistance requirement is complicated by printing on both sides of the laminated circuit board.

Test for insulation resistance as conducted by Synthane Corporation.

Other Properties Influence Choice of Laminates

There are many other properties of a laminate which help to make miniaturization practical. For example, miniaturization brings the holes for terminals closer together, a result usually accompanied by a reduction in the size of holes. Punchability of the laminate, therefore, becomes an important consideration. Mechanical strength, after punching, is also worth attention.

In addition, climatic conditions greatly affect electronic equipment. Frequently, laminated plastics must retain their excellent characteristics even under the influence of heat, cold and change of humidities.

Choice of a Synthane laminate with good insulation resistance will finally rest upon the atmospheric conditions of the application, mechanical, electrical and chemical properties required, and, to a degree, upon the economics of the situation.

Synthane Laminates for Insulation Resistance

Usually high insulation resistant Synthane laminates for printed circuits are processed with selected core and surface sheets to obtain the proper balance of electrical and moisture resistance values and to provide an excellent bonding surface for the metal foil.

Synthane Grades G-10 and G-11 (glass epoxy grades) are the top plastic laminates for insulation resistance. G-11 is the stronger flexurally at elevated temperatures. Synthane Grades XXXP, XXXP-IR and P-25 have very good insulation resistance, and are easier to machine and cost less than the epoxy grades. Grade P-25 may be cold punched. Where there must be high impact strength as well as good insulation resistance Grade N-1 may be the logical choice.

Applications: Among the high insulation resistance applications of Synthane laminates are wiring cards for computers, printed circuits for television, switch rotors, automation circuits, automobile dashboard wiring.

You are urged to write directly to us or to call in a Synthane representative for help in choosing the proper grade for your application.

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"That's why we switched to Ostuco tubing made to our *exact specifications*. We like its availability in truly *small minimum quantities*. And with its consistently close tolerances, shipment after shipment, Ostuco tubing has *cut our machining time over 50 percent* . . . "

This is an actual case history of a manufacturer with a severe inventory problem. He required special tubing grades in minimum quantities. If you're faced with a similar situation, it's time you contacted your Ohio Seamless representative, listed in the Yellow Pages, or the mill at *Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.*

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BURGMASTER six-spindle drill installation (left) at new GE computer plant at Phoenix, Ariz., is programmed for automatic drilling of any of 124 different computer back panel wiring boards. Right: Punched tape for Burgmaster drill is programmed by computer methods not only for automatic drilling but also to determine the shortest distance of wiring runs on the boards. The drill press is enclosed and the room it stands in can be darkened when the machine is used to produce circuits on photographic film.

Assembly line techniques for computer production

Automatic drilling, a novel soldering operation, and faster memory core assembly are among the results of GE's successful attempt to apply assembly line techniques to computer production.

GENERAL Electric's new computer plant at Deer Valley Park, Phoenix, Ariz., features a number of advanced production methods, such as tape-controlled tools and semi-automatic printed wiring board lines. The results so far have been very promising, manufacturing engineers told SPACE/AERONAUTICS. The reported savings from some of these operations are of particular interest because computers, for which "one of a kind" production is the rule rather than the exception, normally don't lend themselves to assembly line techniques.

A good example of GE's approach is the tape-controlled Burgmaster drill press operation for making back panel wiring boards. GE, which does most of its printed wiring board production in its own plant, uses printed wiring board methods to make these back panels, into which the various logic circuit boards are plugged. Its setup can be used either for making circuit patterns, for etching, or for drilling holes.

At present, the six spindle machine is programed to drill automatically 2400 holes of three sizes in 124 different types of backplates. Holes are drilled in 3/16-in. epoxy at the rate of 15-20 per minute, with a tolerance between holes of ± 0.002 in. For an 0.029-in.-diameter drill, hole tolerance is ± 0.004-in.

For producing any of the 124 different circuits, one of the spindles is fitted with a light source. A photographic film is placed under the drill (located in a small, light-tight room to allow a darkroom arrangement) and automatically

more on next page

HEAT in military applications

HUNTER ENGINE HEATERS

starting aids for internal combustion engines

Hunter Engine Heaters, designed and manufactured in conformity with military requirements, are standard winterization gear for engines in military vehicles, hydraulic test stands, battery starting carts, generator sets, compressors, other ground support and special purpose equipment, etc. They burn any type gasoline or JP-4 fuel, with cold starts as low as —65°F. Input ranges from 30,000 to 90,000 BTU/Hour. Both uncontaminated and exhaust heat is utilized. Compact, light-weight, high capacity units, they deliver high temperature, high volume air as required for specific applications.

MODEL UH-86 This heavy-duty model has 90,000 BTU/Hr. input for delivery of high volume, high temperature air against extreme resistances to the engine, battery and lubricating oil • starts to —65°F under the most extreme conditions • used on PE-90, PE-150 and PE-200 Engines employed in ground support equipment such as C-26, MD-3A, MA-3, hydraulic test stands, battery starting carts, etc. • weighs 38 pounds, less than 27" long, 8" diameter • burns ¾ gal. fuel per hr., any grade gasoline or JP-4 fuel.

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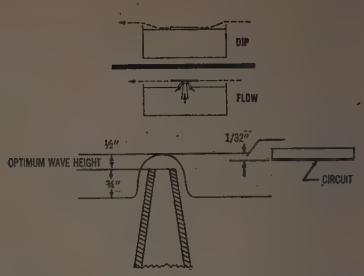


FIGURE 1: Dip and flow solder methods. Closeup of flow solder method shows relationship between height of solder wave, solder level, and circuit path and optimum dimensions suggested by Electrovert.

exposed by the tape control. The film is developed and then used in the etching process.

In the production of printed wiring board assemblies, another innovation is the use of a "flow solder" installation. The flow solder method was devised by Fry, an English firm, and is marketed in the U.S. by Electrovert, of 124 E. 40th St., New York, N.Y. It was adopted, GE engineers state, to overcome the dross problems that have plagued most other types of circuit-board soldering.

As *Figure 1* shows, in this method the solder is pumped up from below the surface to form a standing wave of solder about an inch deep. The solder is pumped up rapidly enough so that it is dross-free as it joins the component leads to the copper circuit pattern.

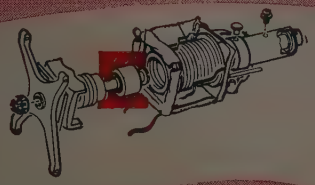
Flow solder eliminates icicling effect

Dip-soldering, which involves lowering the whole board into the solder surface, GE engineers note, tends to cause icicling. Flow solder, on the other hand, can be adjusted to eliminate icicling and so the need to remove excess solder by hand, they state. Their experience also indicates that flow solder, because of its shorter time cycle, minimizes the tendency to unwanted cross-connections.

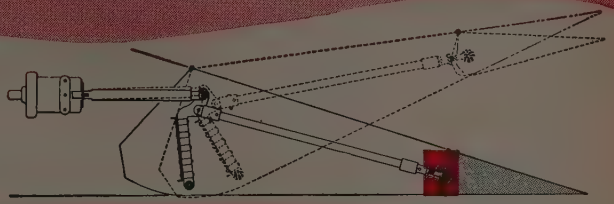
The installation, it's claimed, has also reduced the degree of thermal shock to the board, to which diodes, transistors, etc., are sensitive. On the debit side, setting up such a unit can be costly. However, engineers say, in this case indica-

more on page 92

SHAFER® BEARINGS CARRY THE LOAD

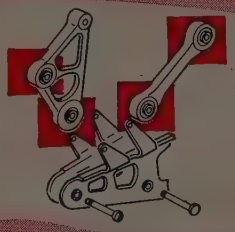


Elevator flight controls

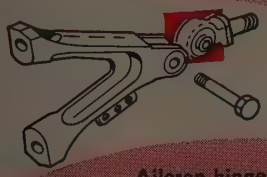


Aileron trim and servo tab control system

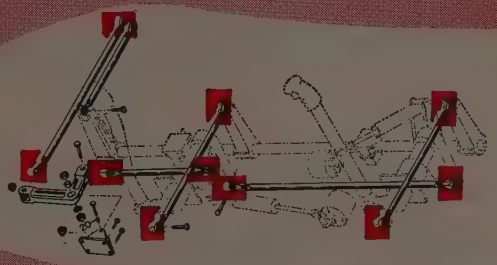
Main landing gear fulcrum and linkage



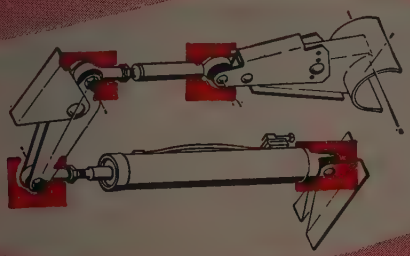
Wing flap hinge and linkage



Aileron hinge



Helicopter flight control group



Hydraulic actuator linkage

Helicopter blade pitch control link

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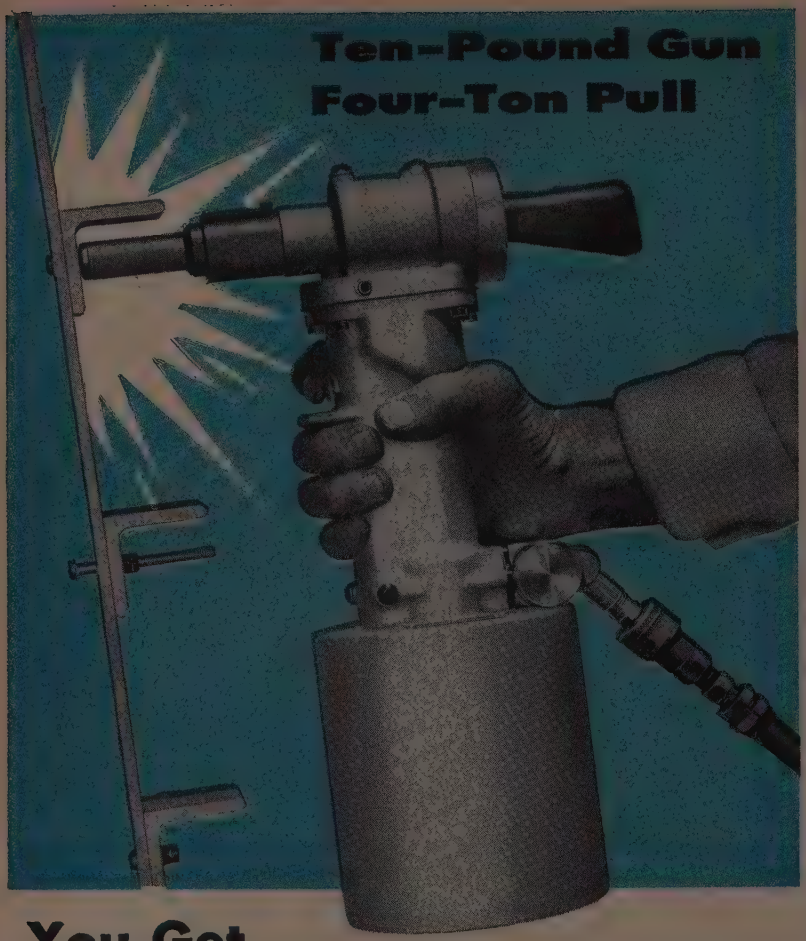

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The new Cherry G-85 lockbolt gun is designed to give you maximum pulling power with less weight. Its simplified rugged construction assures low maintenance costs. The gun weighs only 10.5 pounds, which reduces operator fatigue.

No special air supply is required with this lightweight gun, because it develops this high capacity at normal line pressure.

As the leader in the field of special aircraft fasteners, Cherry Research and Development department has produced this new lightweight, high capacity gun to increase the efficiency of installing lockbolts.* The G-85 gun may be adapted for setting stainless steel, monel, aluminum and carbon steel Cherry blind rivets.

For information on the new Cherry G-85 gun write Townsend Company, Cherry Rivet Division, Post Office Box 2157-P, Santa Ana, California.

*Licensed under Huck patents RE22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049 and 2,754,703

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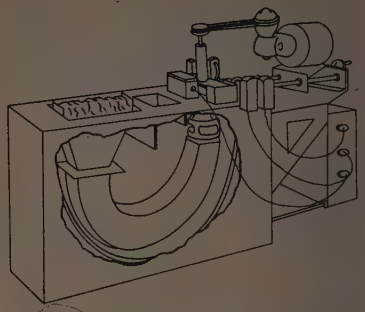

FLOW SOLDER machine with arrangement for pumping solder wave from below the surface of the solder bath.

TAPE-CONTROLLED Wire-wrap gun is slated for use in interconnecting logic wiring.

tions are that the smaller number of rejects with the more reliable new process will make up for the added installation cost.

Figure 2 shows the GE flow solder line. The conveyor is an endless chain driven by a sprocket and gear reducer drive. Speeds up to 10 fpm can be obtained. The boards are placed in Teflon-coated welded-steel pallets that run on a track. The pallets are of standard width, with provisions for length inserts for the three major types of boards run at the plant.

The boards are preheated with infrared

The boards are fed into the pallets and then preheated with infrared to a minimum of 135 deg F. For a speed of four fpm, infrared exposure time is about one minute. This operation gets the board hot enough to drive the flux solvent off rapidly when the flux spray hits the board surface. It accelerates the solder process and gives a better joint.

Flux is sprayed on by a regular Pasche spray gun with gravity feed regulated at 40-lb air pressure. At present, Kester 15-71 flux is used. A control unit turns the spray gun

more on page 94

PIONEERING IN
SOLID PROPULSION SYSTEMS
From the first American jet-assisted airplane takeoff to the first of our second generation guided ballistic missile systems, the Jet Propulsion Laboratory continues to be an active pioneer

In August 1941, America's first jet-assisted airplane takeoff was accomplished with an Ercoupe monoplane, using JPL developed solid propellant rockets. Scientists at JPL shortly discovered that a powdered perchlorate oxidizer, mixed with a liquefied plastic fuel binder, could be cast directly in plastic-lined light-weight motor cases. Thus a safe and cheap method was now available for preparing large internal-burning composite propellant charges. This basic process became the foundation for the modern solid propellant industry.

In 1954, U. S. Army Ordnance requested JPL to develop a compact, rugged long-range guided missile weapon system that could be transported, aimed and fired as simply as a cannon. Within five years, JPL perfected the **Sergeant,** the first of America's second-generation guided ballistic missiles. In January 1958, clusters of small-scale **Sergeants** helped launch America's first earth satellite, the JPL built **Explorer,** which provided vital space environment information.

Now under the direction of the National Aeronautics and Space Administration, the experienced JPL research and development team continues to apply solid propellant vehicles for space exploration.

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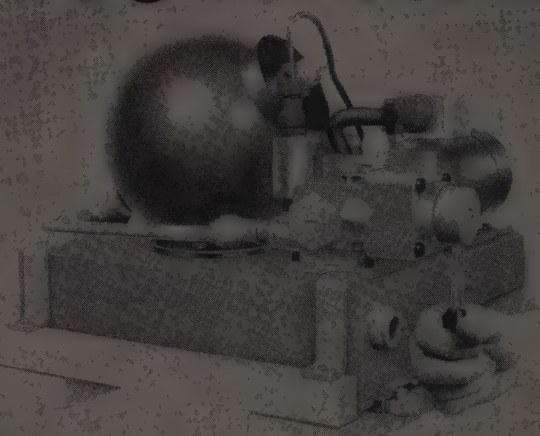
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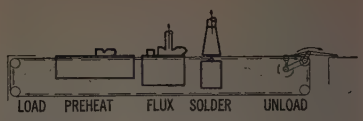

FIGURE 2: GE Computer Department's printed-card flow solder system.

VIBRATING device under plastic seating jig is used for sorting memory cores. Cores are vibrated into the jig, then the operator passes wires through as shown. This method is still in the test stage, but is expected to be used in production in the near future.

on only when a card is on the pallet.

The gap between the spray and solder operations must be carefully calculated for the best results. The solder temperature and the speed of feed needed to minimize exposure also are important considerations. The correct formula must be worked out for each board, depending on the type and density of material and other factors. In current work, Eutectic 63-37 solder is being used at a temperature of 500-600 deg F.

The logic wiring interconnections are performed by the Wire-Wrap method (see *S/A, "Automated Wire-Wrap Cuts Production Costs in Half," May 95, p. 59*). At present, this is a manual operation, with the connections called out on a wiring chart.

Soon to be introduced, however, is a tape-controlled Wire-Wrap gun. In this case, the instructions are put on punched tape. A matrix of small light bulbs is placed behind the terminal blocks that are being wired. The lights are synchronized by the tape to show the operator which two connections to make at a time and stop the gun the mo-

more on page 96

The PLANE

New Douglas DC-8 Jetliner, soon to enter commercial service with 18 of the world's leading airlines. The four-jet DC-8 cruises at 560 to 590 mph, carries 118 to 176 passengers, and will cross the Atlantic non-stop from New York to Paris in just over six hours. Fuel capacity on international flights exceeds 21 thousand gallons.

The PROBLEM

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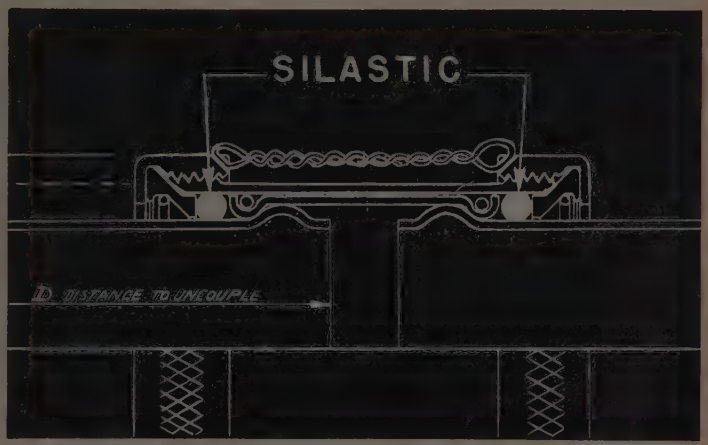

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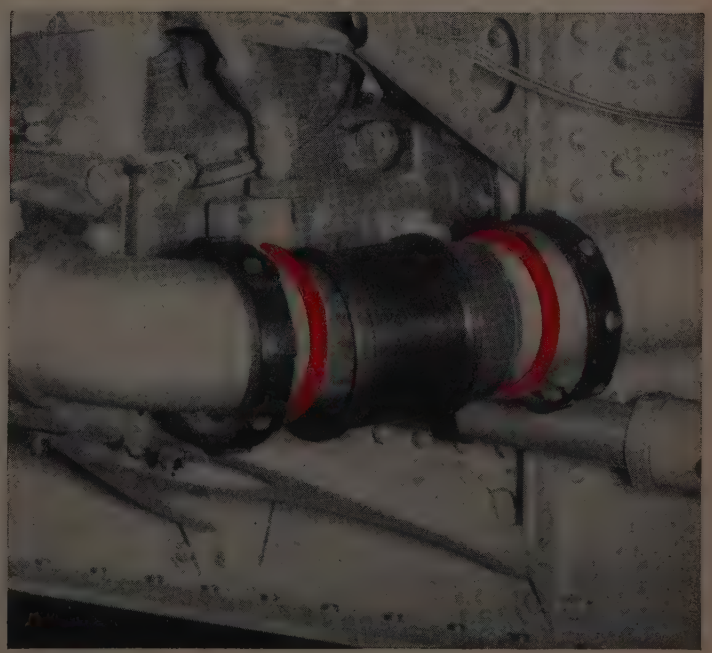

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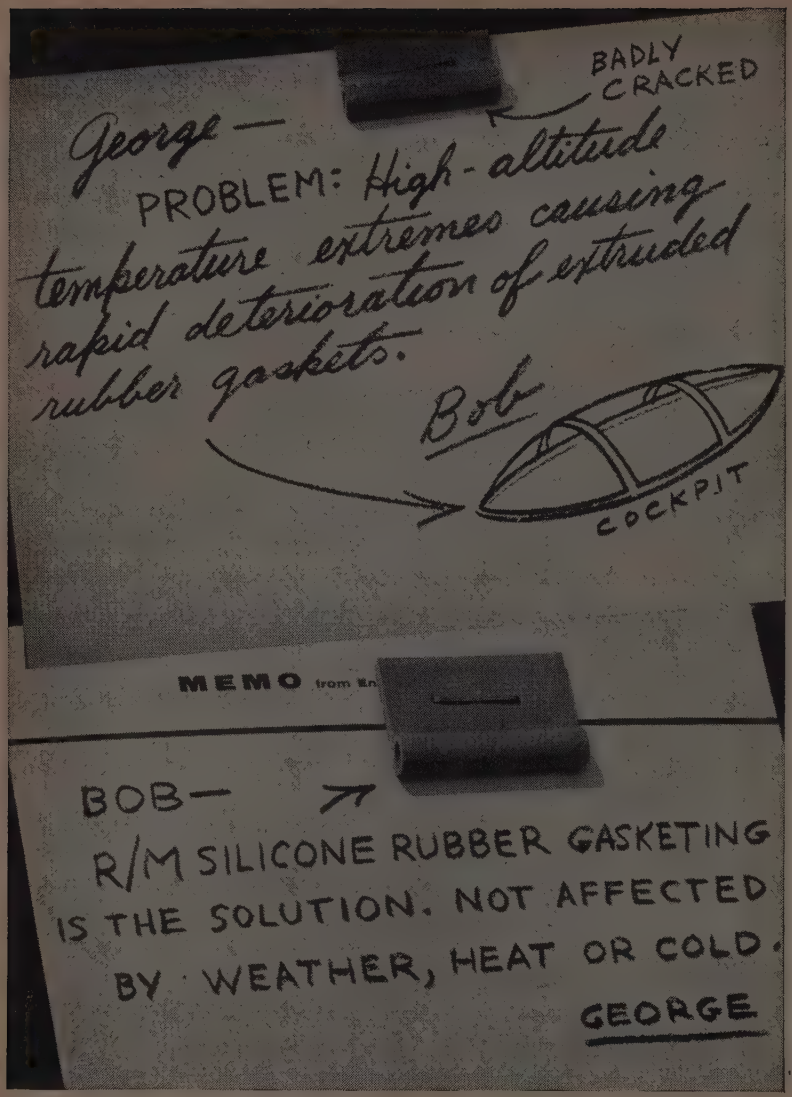
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GE flow solder line in operation. Note empty pallets moving back to starting point on conveyor under table.

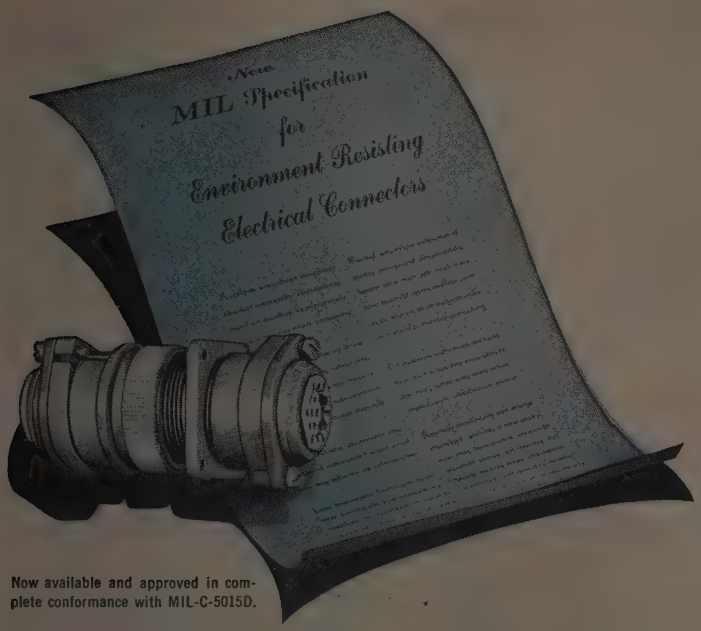
ICICLING of dip-soldered board (left) is eliminated in flow soldered board (right), GE Computer Dept. states.

ment the operator tries to connect to the wrong lead.

GE studies indicate that tape-controlled Wire-Wrap will provide appreciable savings. With some 75,000 connections to be made in some cases, one mistake by an operator can be very costly. It might not show up until the systems or intermediate test stage is reached, and a highly paid engineer might then have to spend a great deal of time before he could track it down. An incorrect connection, it's pointed out, might not only disturb one circuit, but also add information to other circuits to throw the whole summary off.

GE also has a new method for assembling memory cores. Formerly these small cores were laboriously sorted and assembled manually. GE now uses a vibrating device for core sorting. As *Figure 3* shows, plastic jigs are used that have indentations for seating the cores. The vibrating device vibrates the cores into these seats in a matter of seconds. The operator can then easily pass the connecting wires through the cores to complete the assembly.—**IS**

NEW BENDIX MS-R ENVIRONMENT RESISTING ELECTRICAL CONNECTOR



Now available and approved in complete conformance with MIL-C-5015D.

This new connector answers the demand from the aircraft industry for a shorter, lighter and more reliable environment resisting connector. This connector will inactivate practically all other MS types and the Military has assigned a new class letter R to insure incorporation of this better connector in all new designs.

An important reliability feature of the new MS-R connector is an "O" ring at the main coupling joint which provides for the best possible sealing and more positive inter-facial compression and assures complete performance compatibility among all approved MS-R connectors. Establishment of the MS-R connector as the "universal" military connector is testimony to the record of previous MS environmental resistant connectors using resilient inserts as pioneered by this Division. In the Bendix* connector, wire sealing is accomplished by an exclusive slippery rubber grommet which permits convenient wire threading and grommet travel over wire bundles.

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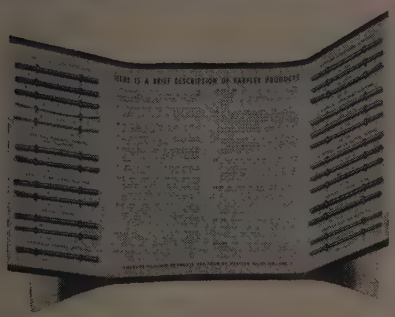

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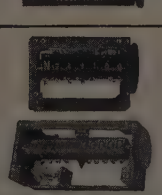

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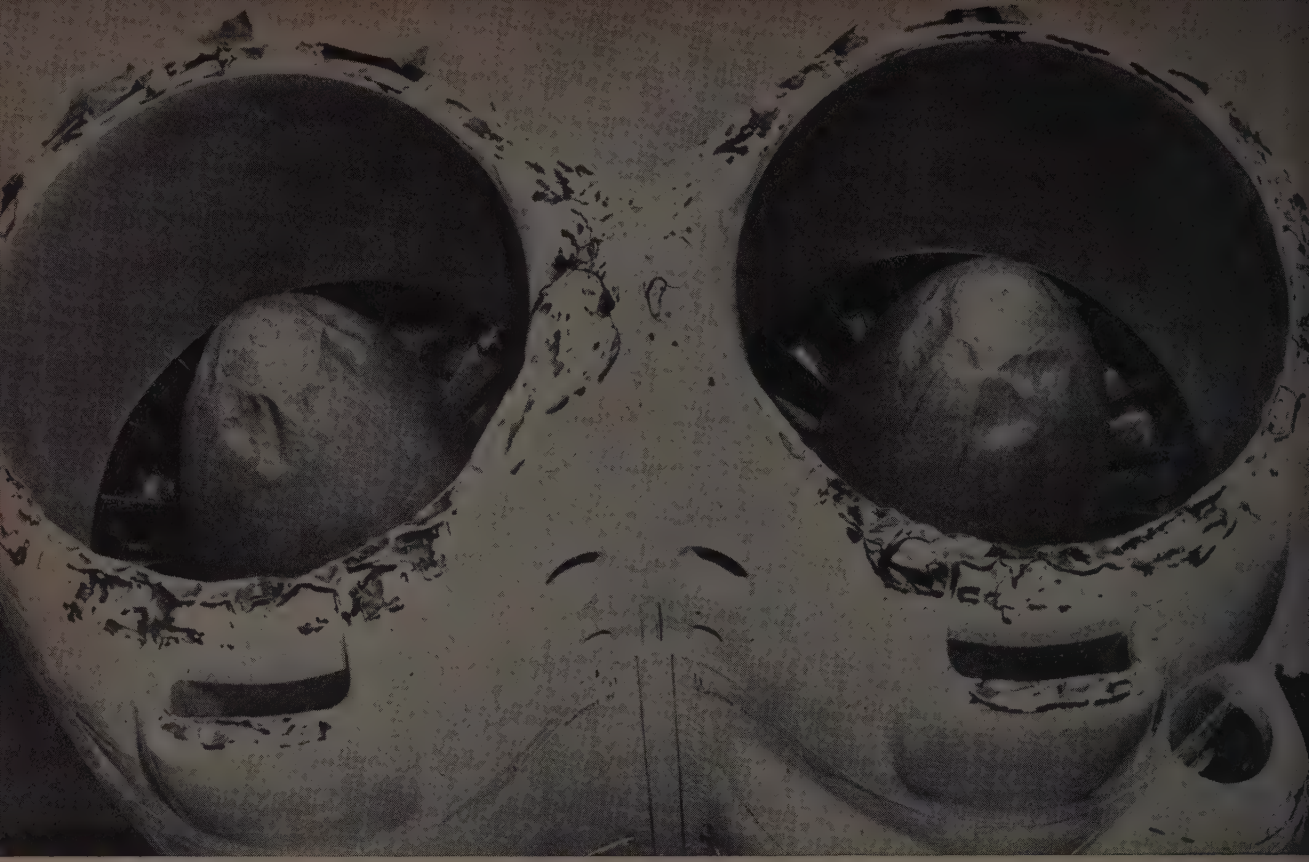

J-57 Titanium engines save nine-man crew in their $8-million B-52

At 8,000 feet, the B-52 ran into a small and very violent frontal area. Suddenly the airplane was pelted with hailstones the size of baseballs. Flying at 400 miles an hour the damage to the B-52 was terrific.

The windshield smashed. The radome was torn away. The radar antenna was demolished. Wing edges were hammered flat. Holes were punched in the wings and engine nacelles. Flying metal was sucked into the engines and disappeared. Some of the electrical system failed and most of the instruments were out. The aircraft went momentarily out of control.

Major W. F. Zerdecki, the air commander, struggled with the controls. Captain Charles L. Borgeson, Jr., the instructor pilot, sent out the distress call. The crew prepared to bail out.

By this time, the shuddering aircraft had already bucked through the storm. The eight Pratt and Whitney titanium version J-57 engines were still giving full power. Major Zerdecki climbed the B-52 to 23,000 feet where he rendezvoused with a KC-135 tanker. The B-52 crew tested their controls by instrument readings relayed by the tanker crew. The light and powerful titanium engines kept the shattered aircraft aloft for almost two hours after it hit the storm.

The performance of the J-57's in bringing safely home the nine-man crew in their $8-million ship, was described by Brigadier General Nils H. Ohman, 19th Air Division Commander:

"The engines put out all the power required. They performed perfectly. If they hadn't, Major Zerdecki would never have been able to fly the ship back."

Carl Cooper, Pratt & Whitney technical representative, reported: "All eight engines had ingested metal. Magnesium cowling pieces shattered as they went

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through the engine. Six of the engines were found to have bits of cowling metal one-eighth of an inch long at the end of the high compressor assembly and pieces of magnesium approximately the same length were found stuck to the first stage turbine blades. The J-57 engines, though slightly damaged, were still serviceable and satisfactory for continued, limited, safe operation. The damage was repairable with a minimum of time and effort."

Since 1954, some 5000 titanium engines have been put into service containing material supplied by Titanium Metals Corporation of America. More than 500,000 hours service time have been accumulated with no reports of failure of the titanium parts.

GREAT STRENGTHS...The strengths of titanium, coupled with its light weight (density 0.16 pounds per cubic inch), have meant valuable fuel economies and increased payloads. At the same time, the excellent corrosion resistance of titanium has reduced costly maintenance and parts replacement.

Steadily declining prices; advances in machining, welding and heat-treating techniques; and development of new alloys have combined to maintain titanium's role as an important engineering metal in the new engines now in design or advanced development.

These same advantages also make titanium metal an economical material of construction for the dead-weight area known as airframe. For example, heat-treated titanium forgings can cut structural weights almost in half.

Titanium Metals Corporation of America has dedicated its full resources to development and production of high-strength aircraft quality material and the technical assistance required to make design potentialities of the metal production realities.

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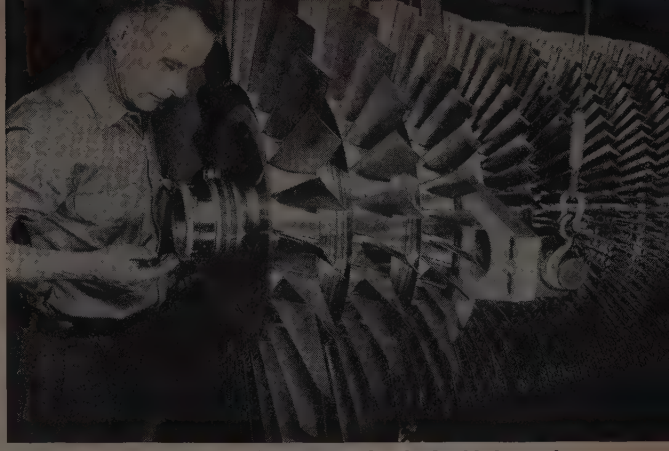
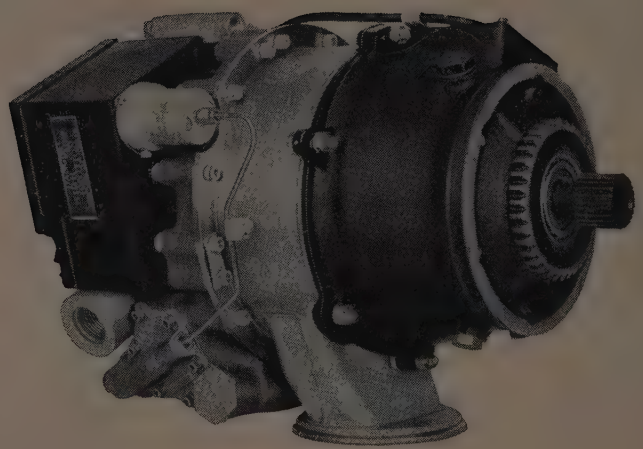


J-57 ROTOR ASSEMBLY, with wheels, blades and spacers forged and machined from TMCA titanium alloy Ti-6Al-4V. Now *new* alloys, such as Ti-7Al-4Mo —already in commercial production—extend useful temperature range and meet higher creep strengths required for engines in design or advanced development stage.

THIS INTERMEDIATE COMPRESSOR CASE ASSEMBLY is used in fighter versions of J-57 engine. Fabrication techniques include ring-rolling, welding, machining, stretch-forming, and piercing. Use of titanium saves 443 pounds per compressor.

STATOR HOUSING of titanium alloy Ti-5Al-2.5Sn, shown here in various stages of fabrication from rolled and welded ring to finish-machined part, provides important weight savings to J-57 engine.



The FAS 500-1 fuel-air jet engine starter makes Convair's F-106 fighter-interceptor ready for emergency scrambles. In as little as 12 seconds, this 48-pound, 165 hp. unit can bring the mighty J-75 engine compressor to 2500 RPM for starting, and sustain 3000 RPM several seconds more for acceleration and safety.

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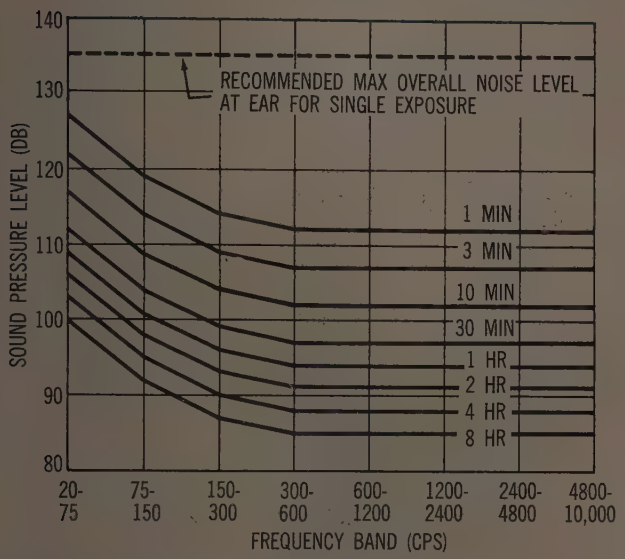

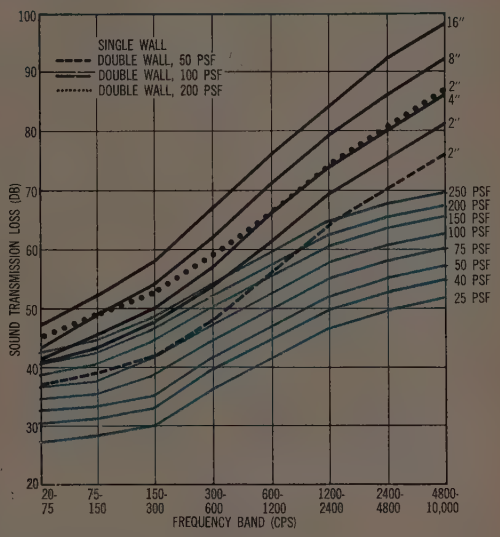

FIGURE 1: Safe daily noise exposure for 25-year period (left). For levels 10 db higher, provisions for hearing protection are mandatory. (Decibels for this graph and Figure 3 are referenced to 0.0002 microbar as measured on the C-scale of a standard sound level meter. Right: Transmission loss of walls of different surface weights, with several spacings shown for 100-psf double walls. For spacing of 50- and 200-psf double walls not shown here, measure the difference between the two-inch-spacing curve for the desired wall weight and the 100-psf-wall curve at the desired spacing and add or subtract this difference.

How to protect yourself against noise

As every space/aero test engineer knows only too well, things are getting noisier all the time. Yet he's got to hang on to his hearing and his sanity. What can he do? The best idea, of course, is to be far away from the noise. When that isn't possible—and all too often it just isn't—properly designed walls and doors must take care of noise protection.

by Fortune Odend'hal, Vice President—Engineering, Jamison Cold Storage Door Co.*

NOISE protection in industrial activities must concern itself with three noise effects—those on (1) human hearing, (2) human work performance, and (3) spoken communication.

The effect of noise on hearing depends on both the intensity of the noise and the exposure time. As noise intensity increases, the safe daily noise exposure obviously decreases (*Fig. 1*). Furthermore, when the noise contains audible discrete frequencies (such as the intake whine of a compressor), the tolerable noise level is lowered—by 10 db in the case of the curves in *Figure 1*. The reason for this is that the human ear is more sensitive to single-tone than to broad-band noise.

Figure 1 shows, for example, that a person could be exposed to a noise level of 80 db for eight hours

* Jamison Cold Storage Door Co., Hagerstown, Md.

more on next page

S_T/S_W	Surfaces of Receiving Room Covered With 1 In. or More of Acoustic Absorption Material		
	None	Ceiling Only	Ceiling & Half of Total Wall Area
< 3.6	1	3	5
3.6-5.6	2	4	6
5.7-8.9	3	5	7
9-14	4	6	8
> 14	5	7	9

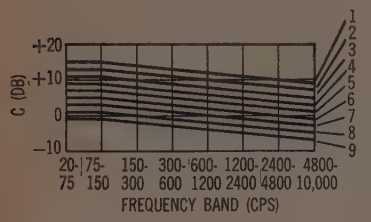

FIGURE 2: Correction term C adjusted according to S_T/S_W and acoustic surface treatment, where S_T is receiving room surface area and S_W is wall surface area common to generating and receiving rooms.

a day and five days a week for 25 years without auditory damage. On the other hand, his hearing may very well be impaired if, on every working day in 25 years, he is exposed to just half an hour if 100-110-db noise in the high frequency octave bands.

Contrary to popular belief, steady source or background noise does not seem to have any significant effect on man's ability to do either simple or complicated work. High noise levels, however, do produce annoyance and fatigue. Intermittent noise with a high peak and single-tone noise generally are more irritating than broad-band noise.

Work performance is more liable to be affected indirectly—through the effect of noise on spoken communication. Most intelligibility in human voices is contained in the 600-1200-, 1200-2400-, and 2400-4800-cps frequency bands. When the noise levels in these bands are too high, they interfere with speech and so with work performance.

At an average noise level of 45 db in each of the three frequency bands from 6000 to 4800 cps, you can carry on a conversation in a normal voice over 2-4 ft. When the average noise level goes up to 55 db, a raised voice must be used over this distance—a normal voice now carries only ½ ft. When the noise level reaches 60 db, raised voices must be used at all times and conversation becomes a nuisance.

The design noise level curves of *Figure 3* show what mixtures of low and high frequency noises are acceptable. They apply to many industrial activities but contain more low frequency noise than is desirable for office areas. They cover the complete range of hearing from 20 to 10,000 cps (speaking in terms of overall levels rather than individual tones), which, for practical purposes, is divided into eight frequency bands. Noise protection calculations—as for walls and doors between two rooms—must cover this entire range (with a tolerance of 1-2 db for one or two of the eight bands for any given wall design).

"Sound transmission loss" is critical

The effectiveness of any wall or door designed to protect the occupants of one room from the noise in an adjoining room is known as the "sound transmission loss." This loss must equal or exceed the desired noise reduction, or difference in average noise levels between the noisy (generating) room and the quiet (receiving) one, plus a correction term (C) *for each frequency band* (with all units expressed in decibels).

C has been approximated for a reasonable range of room conditions, and is shown as a function of the eight frequency bands in *Figure 2*. It is influenced by two parameters: (1) the ratio of the surface area (walls, ceiling, and

more on page 104

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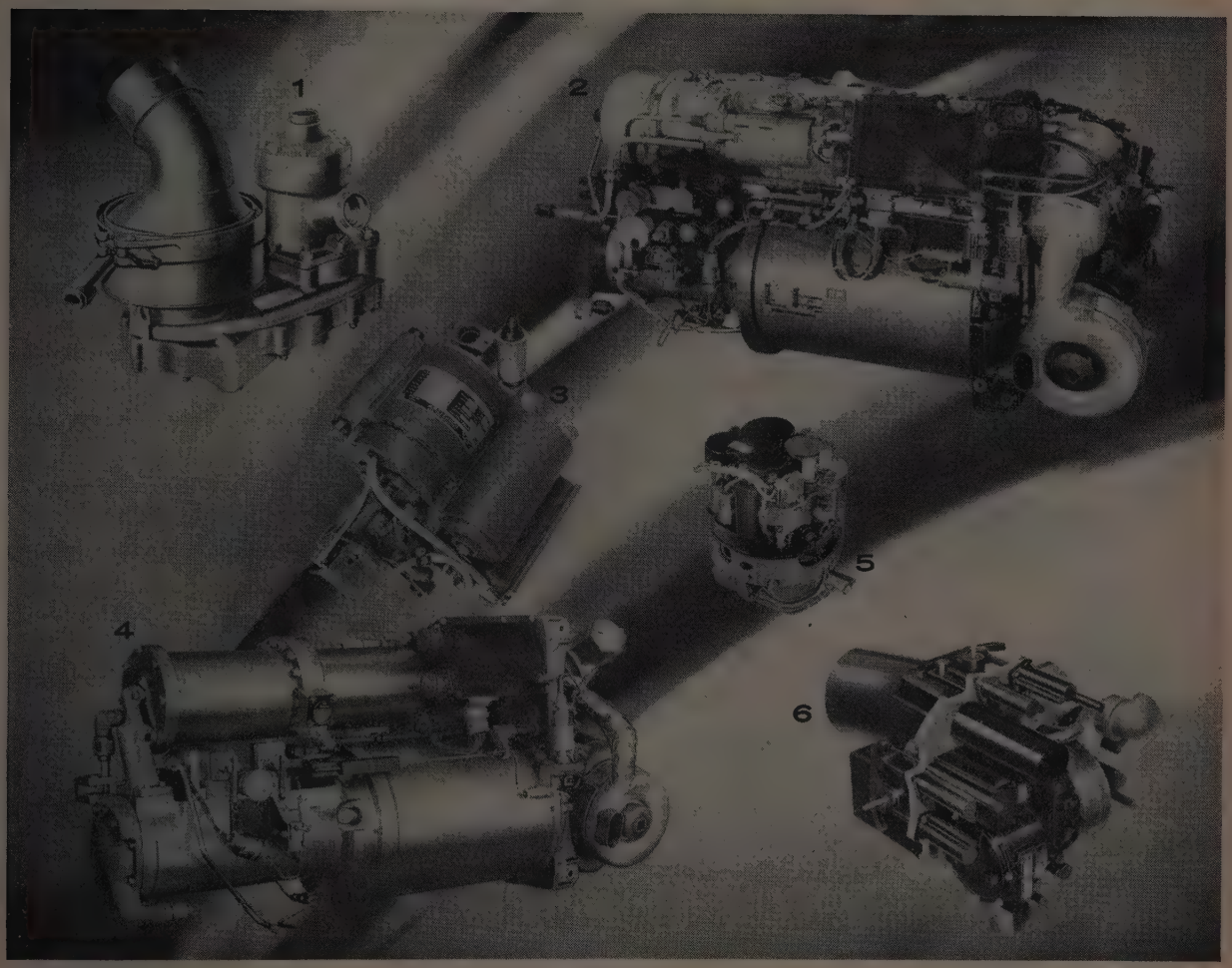

1. *Solid propellant—hydraulic output* 2. *Liquid propellant—hydraulic and electric output* 3. *Solid propellant—electric and mechanical drive output* 4. *Liquid propellant—hydraulic and electric output* 5. *Solid propellant—hydraulic and electric output* 6. *Solid propellant—hydraulic, electric and steering outputs*

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The several units pictured above provide hydraulic, electrical and/or steering surface control depending on the customer's requirement. Delivered horsepower ranges from 1.2 to 35 h.p. over hot gas operating durations from 30 seconds to 20 minutes. Electrical regulation is maintained as closely as ±½%. A significant advance in missile APUs is unit #6 pictured above. This package represents the first integrated hydraulic and electrical power unit providing a steering surface actuation system.

These tailored systems utilize the extensive hardware experience and complete laboratory, test and production facilities of AiResearch needed for quick and efficient quantity production of complex APU systems. AiResearch is the world's largest and most experienced manufacturer of lightweight turbomachinery—the key component of its APU systems. Your inquiries are invited.

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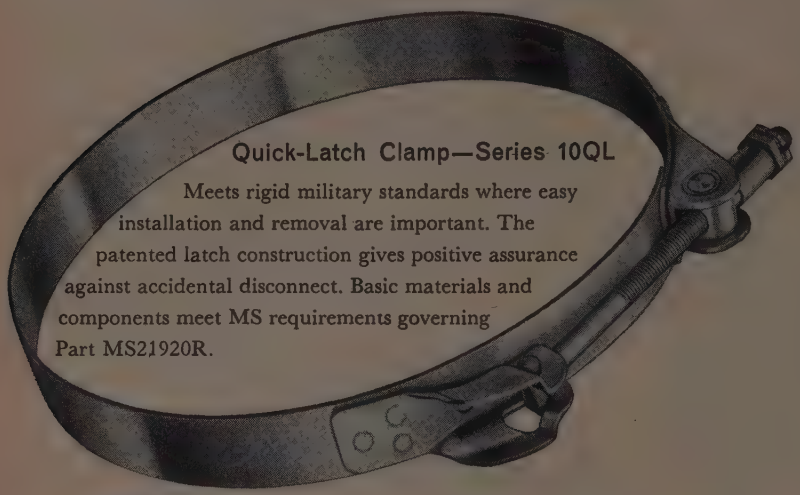

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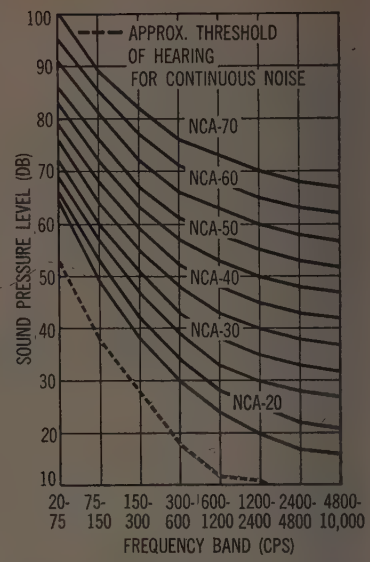

FIGURE 3: Design curves, or noise criterion averages, for acceptable noise environment in work areas.

floor) of the receiving room to the wall surface area common to both the generating and the receiving room and (2) the amount of acoustic absorption material used in the receiving room. It may be small or negative for a large receiving room well covered with sound-absorbing material and sharing only a small wall area with the noisy room.

Double walls not always of same weight

A variety of wall designs and materials can be used to be used to get a given sound transmission loss. You can have either a single wall or a double wall, which is two single walls *structurally isolated* from each other by an air space. Materials can be poured, dense concrete; well-mortared brick; or solid concrete. Even dense hollow concrete can be used if filled with sand, mortar, or cement. Wall density is more important than wall thickness.

Figure 1 also shows the transmission loss achieved by various wall designs, with the effect of the materials expressed in terms of wall surface weight. A wall of dense solid concrete with a surface weight of 50 psf is about four inches thick. Double walls do not necessarily have to be of the same weight, but the heavier wall should not weigh

more on page 106

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The compound gear you see here is probably the finest example of precision rocket power gearing ever produced. It gears the turbo-pump in a Rocketdyne liquid propellant rocket engine. Tooth-to-tooth spacing is a maximum of three ten-thousandths, a tolerance on the smaller gear that can't be met with conventional grinding equipment. This gear delivers more than 3000 horsepower and turns from zero to over 10,000 rpm in less than a half-second. Only the finest precision equipment and craftsmanship can produce a gear to such rigid specifications. It is one more example of "precision" at I.G.W.

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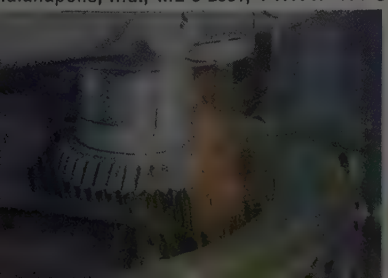

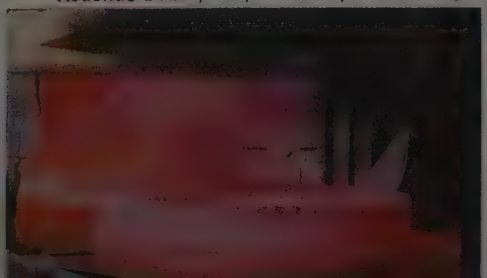

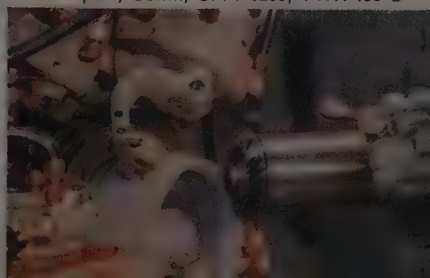

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Other Collins space electronic projects include the communication-navigation system for the X-15, moon relay communication studies, and satellite tracking facilities.

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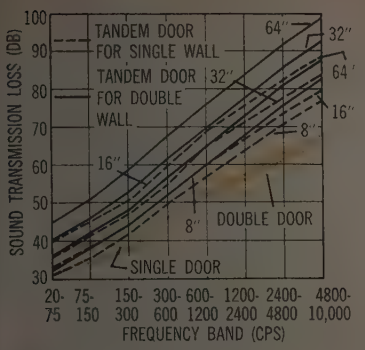


FIGURE 4: Transmission loss of several Jamison door designs.

SINGLE sound reduction door in tandem design by Jamison.

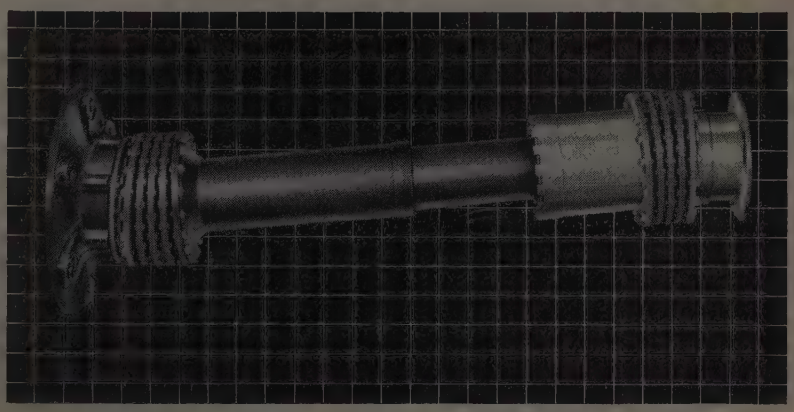
more than twice as much as the lighter—the transmission loss of two 75-psf walls is roughly the same as that of a 100-psf wall plus a 50-psf wall.

Transmission loss may be lower for door

In most cases, the wall separating a noisy room from a quiet one must have a door—which may be either a single door, a double door, or a door in tandem (which is essentially two single or double doors separated by an air space and may be installed even in a single wall). *Figure 4* shows the transmission losses obtained with various doors designed by Jamison.

It should be noted that the transmission loss of a door may safely be lower in each frequency band than that of the wall in which it is installed—*if the door area is less than 45 per cent of the wall area.* The loss may be two, six, and as much as 10 db lower if the door area represents, respectively, 25, 10, and five per cent of the wall area. Circle No. 63 on Reader Service Card for more information about sound reduction doors.—End

BENDIX FLEXIBLE POWER DRIVE SHAFT SOLVES MISALIGNMENT PROBLEM



POSSIBLE IN-USE DEFLECTION *of a Model 19E29-3 Flexible Drive Shaft. This standard 20-inch-long unit weighs 12 pounds, is rated 42.5 h.p. at 2800 RPM to 11,000 RPM, and includes a torque limiting clutch.*

Transmission of power to accessories mounted remotely from aircraft engines is no problem when one of Bendix Utica's flexible drive shafts is used.

High speeds are possible . . . because of symmetrical shaft design. Two constant velocity ratio flexible joints, made up of high alloy steel diaphragms, permit up to plus or minus 10° intermittent deflection and plus or minus 5° continuous deflection while maintaining rotational balance in the shaft at any speed.

High operating temperatures won't affect efficiency of a Bendix Utica shaft. Unique joint design permits continual operation at maximum speed, at any temperature up to 600° F.

We can solve virtually any power take-off problem using one of our standard or special design flexible shafts. Special designs can be engineered for unusual applications involving almost any degree of misalignment and power/speed requirements. A mechanical disconnect can be provided integral with the shaft to disconnect driven accessories from the driving source.

We've gained wide experience in successfully solving all kinds of intricate drive shaft problems. No matter what your aircraft power transmission problem, you'll get the best answer to it from Bendix Utica.

NO LUBRICATION *is required for flexible torque carrying members. The flexing diaphragms transmit load, with no rubbing or sliding surfaces. They generate no frictional wear and little heat, resulting in long shaft service life.*

West Coast: 117 E. Providencia, Burbank, California
Canada: Aviation Electric, Ltd., 200 Laurentien Blvd., Montreal, Quebec
Export Sales and Service: Bendix International, 205 E. 42nd Street, New York 17, N. Y.

Bendix Utica Division
UTICA, NEW YORK

Bendix AVIATION CORPORATION

Write in No. 86 on Reader Service Card at start of Product Preview Section

Westinghouse equipment drives

How do you move a 30-ton building at a uniform speed regardless of 60 mile an hour winds that might push with or against it? Westinghouse engineers solved this problem when they designed the automatic shelter drive system for the Douglas/USAF THOR IRBM.

Here is the installation—a fool-proof, self-controlled drive system. The operator pushes the forward or reverse button—the system does the rest, quickly—surely. Westinghouse React-O-Verse control automatically compensates for wind pressures to determine the instantaneous power requirement to move the huge shelter smoothly and uniformly, regardless of wind direction or force.

This is additional proof of the results you obtain when you use Westinghouse range of products, engineering knowledge, single-source responsibility and ability to supply a packaged, guaranteed unit.

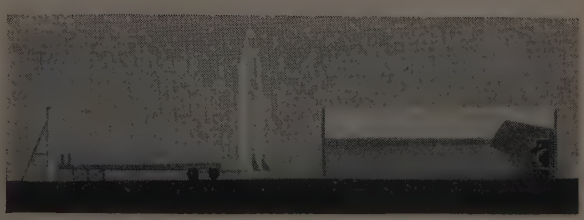
Take advantage of these Westinghouse facilities when designing and building retractable shelters, hardened missile sites, erectors, lowering devices or launchers. Contact your local Westinghouse sales engineer or write: Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania.

An illustration of a hardened missile site, suitable for framing, will be sent you if requested on your letterhead.

J-92030

THOR retractable shelters

The Westinghouse equipment includes: 75-hp crane and hoist motor; d-c magnetic brake; double reduction gear and flywheel unit; React-O-Verse control; pilot generator; manual and automatic switch and controls; and floodlighting.



Typical THOR installation, showing a breakaway view of the drive unit in the retractable shelter, missile, free standing end wall of shelter and missile erector.

YOU CAN BE SURE...IF IT'S

Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS

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Sharp new eye for navigation

SHARPEST new "eye" for flight is the Ryan C-W Doppler navigator. Based on the advanced development of continuous-wave radar, this system of electronics "intelligence" has been pioneered by Ryan and the U.S. Navy for navigation at all speeds. It tells pilots how to fly to any spot on the globe, with speed and precision, and lets them know exactly where they are at all times.

With the Ryan navigator, military aircraft and jetliners can fly a new "electronic skyway" which provides precise separation between planes and conserves time and fuel. And, because RYANAV systems work right down to ground and sea levels, these advantages accrue at take-off, climb-out, descent and landings, as well as enroute.

The Navy has selected RYANAV for installation in six major types of naval aircraft. They are already in squadron use in the Navy's first all-weather anti-submarine helicopters and are being installed in Army aircraft and helicopters, for low-level "nap of the earth" operations.

Reasons for such wide and versatile use are found in the unique features of RYANAV systems: They are the lightest, simplest, most reliable, most compact of their type. They are setting new standards of accuracy, freedom from adjustment, and ease of maintenance . . . opening new areas of navigational, guidance, and orientation applications. Ryan electronics engineering assistance is available upon request, to those who wish to explore these areas.

Ryan's rapid growth in electronics is creating new opportunities for engineers and technicians

RYAN BUILDS BETTER

ELECTRONICS DIVISION

Ryan Aeronautical Company, San Diego, Calif.

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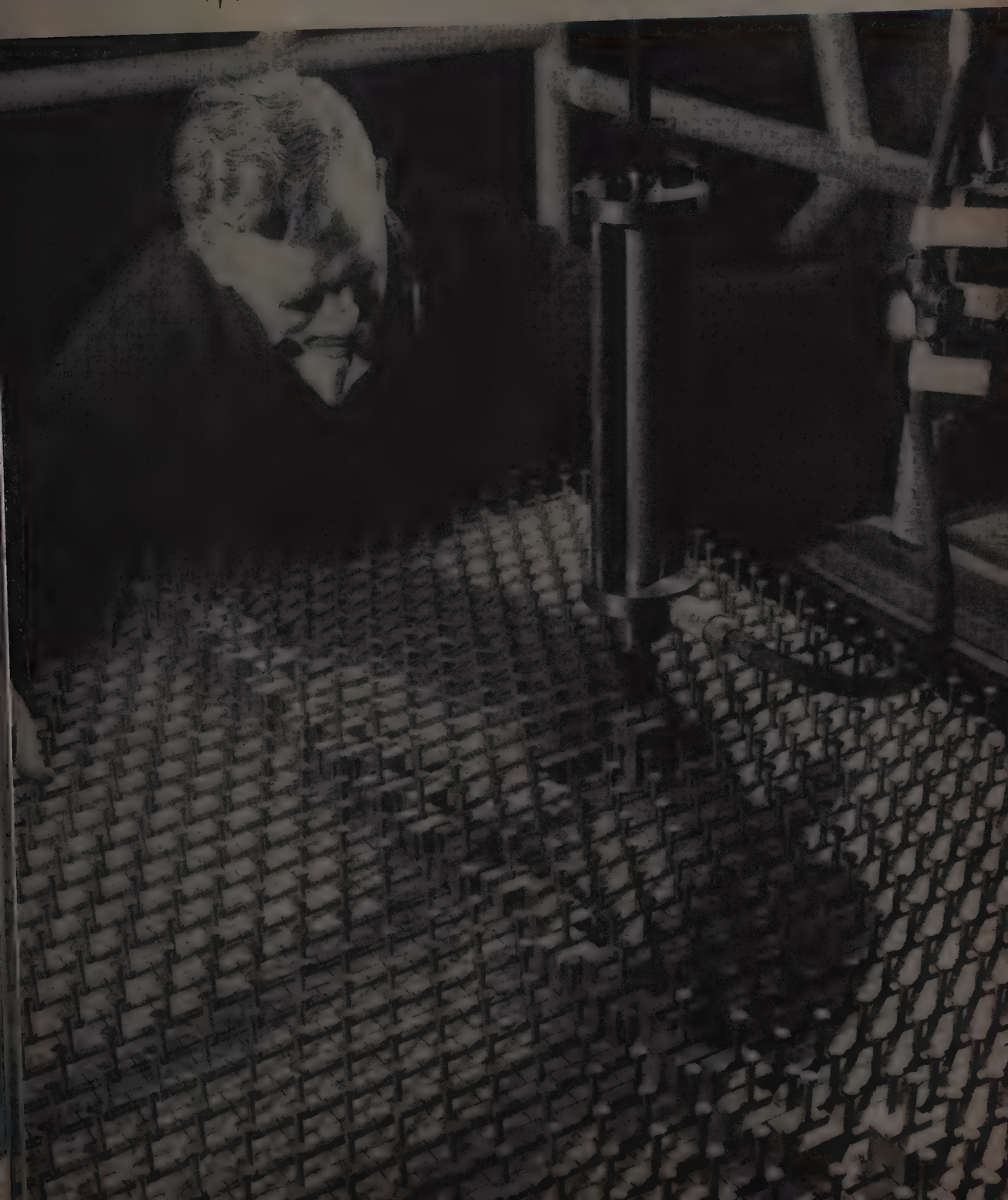
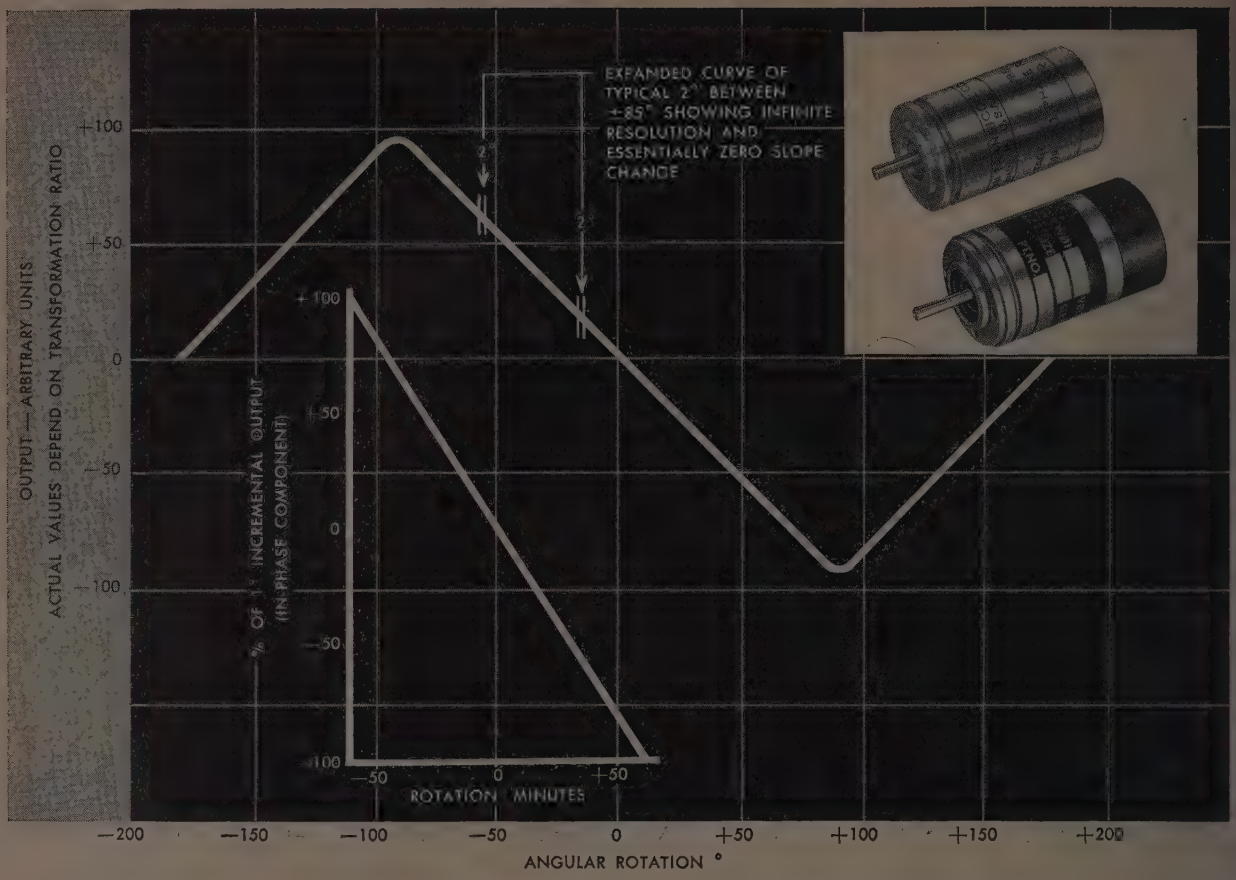
space aero Electronics





Inductive pots give accurate noiseless output with infinite resolution

Weapons systems . . . analog computers . . . proportioning circuits—wherever the limitations of wirewound potentiometers can not be tolerated, these precision linear pots are the answer.

The Daystrom Transicoil Size 8 and 11 Inductive Pots provide extreme angular accuracy for applications requiring linear output and high gain amplification. There are no brushes wiping over turns of resistance wire to generate noise. Grounding problems are eliminated since each phase is electrically insulated from the other. When operated into the correct load, output is linear to within ±0.25% over the 170° (±85° from null) operating range. Output phase is dependent on direction of shaft displacement from null.

Write for complete specifications. Daystrom Transicoil, Division of Daystrom, Inc., Worcester, Montgomery County, Penna. Phone: JUNO 4-2421. In Canada: Daystrom, Ltd., 840 Caledonia Rd., Toronto 19, Ontario. Foreign: Daystrom International Division, 100 Empire Street, Newark 12, New Jersey.

TYPICAL CHARACTERISTICS

	Size 8		Size 11		
Volts	26	26	26	26	115
Excitation Power (watts)	.16	.16	.15	.15	.45
Excitation Current (ma)	27	27	30	30	24
Excitation Frequency (cps)	400	400	400	400	400
Sensitivity (v/°)	.107	.346	.107	.346	.620
Null Volts (mv)	7	20	7	20	40
Transformation Ratio	.350	1.130	.350	1.130	.458

DAYSTROM TRANSICOIL DIVISION OF DAYSTROM, INC.

Representatives in Canada and Other Foreign Countries

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MOLECULAR ELECTRONICS development contract for $2 million was given to Westinghouse Electric by WADC. Work will be done mainly by the company's Research Labs, Semiconductor Dept., and Materials Labs. Air Arm Div. will serve as project manager.

Keystone of Westinghouse's approach to moletronics is its revolutionary method of growing germanium crystals. Instead of growing them in ingots, which require subsequent cutting and polishing, the company has devised a technique of forming the crystals in thin, uniform, highly polished flat ribbons. The material can be used then in the same form in which it is grown.

NOVEL PROCESS, called "dendritic growth," resulted from work of two physicists at Westinghouse's Research Labs. ("Dendritic" stems from the Greek word for "tree." It indicates the way in which the minute impurities branch out in tree-like fashion in the germanium.) Westinghouse researchers expect their method may lead to electronic equipment one-thousandth the size of anything now in existence.

One of the devices designed to the new concept is a telemetry subsystem for measuring the intensity of light. Incident light is made to modulate an oscillator, converting light energy into an electric impulse. Conventional transistorized and molecular versions of this device (see *Diagram*) use 14 parts, while Westinghouse's molecular version gets by with just one part.

As in Texas Instrument's silicon solid circuits (see *"Three Pacesetters for Tomorrow's Aerospace Electronics," p.* 135), the germanium crystals would be used to perform functions of various components of conventional circuits.

GE TIMMs micromodules use heat dissipation for operation of vacuum devices

UNIQUE MICROMODULAR concept was revealed by GE's Research Lab at Electronic Components Conference. It involves building heaterless tubes and their circuits on a single, tiny stacked ceramic module. Instead of trying to get rid of the heat dissipated within tightly packed electronic equipment, GE confines the heat and puts it to work operating vacuum devices. The TIMMs (Thermionic Integrated Micro Modules) system takes advantage of thermal energy that would otherwise flow to a heat sink, where it would become unavailable for work.

TIMMs RESISTORS are built into the ceramic modules and consist of a resistive film on the inside of sealed ceramic insulators. Resistors of 1-500 K have been made and have operated stably at 700 deg C, claims GE. Preliminary data shows changes of less than three per cent in resistance in an operating temperature of 550 deg C, and similar stability within a nuclear pile.

Capacitors are of synthetic mica. Tests show a change of less than five per cent over 0-700 deg C. A TYPICAL circuit module 0.33 in. in diameter and 2.6 in. long can contain 10 diodes, 14 triodes, 14 resistors, and six capacitors. It yields an operating circuit density of 250,000 parts per cubic foot. With different operating requirements, 1,000,000 parts components per cubic foot are possible, says GE.

Infrared detector covers 8-14 micron region

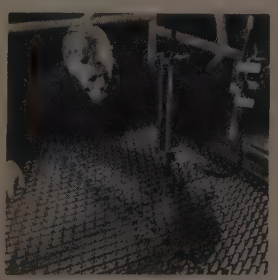
ZIP IR DETECTOR is first fast, sensitive photoconductor-type detector that gives full coverage of 8-14 micron region, according to Perkin-Elmer Corp. Full range of Zip's spectral response is 2-40 microns, with peak sensitivity at around 37 microns. Time constant is less than 0.01 sec.

Material used in the detector is zinc-doped germanium. Liquid helium bath is needed to get quoted response. D* factor (square root of detector's sensitive area divided by noise equivalent power) is 4×10^9 cm^3/W.

■

BALLISTIC MISSILE inertial guidance systems have shrunk in size and weight by factor of 10 over the last five years, AC Spark Plug's director of advanced systems R&D engineering, Dr. J. F. Shea, told World Congress of Flight audience at

more on next page



Cover story—Silver-coated plastic lens developed for Talos guidance radar by Sperry Gyroscope is said to double the system's effective power with 4100 cells it provides twice the signal gain of earlier metal versions.

Las Vegas, Nev. He added that IG accuracy requirements were about five times more stringent for ICBMs than for IRBMs. (ACSP built Thor IRBM's inertial system, will build IG system for Titan ICBM.)

Shea predicted:

- Use of IG by commercial airlines within the next 10 years. (Airline IG, he says, should not exceed 100 lb.)
- Excellent future for IG in space. With IG velocity control, he claims, we could not only guide a vehicle to the moon but we could name the crater we wanted to land in.
- Combinatorial systems—stellar-, Doppler-, and radio-inertial—are the ultimate types for space navigation.

ADAPTIVE flight control system developed by MIT has logged some 42 hours of flight test time. The autopilot is a complete three-axis installation for pitch, roll, and yaw, including rudder coordination to minimize sideslip. MIT's designers believe theirs to be the only actual flight tests of a lateral adaptive control system added to a pitch control system.

Avion's Codes IR search system scans a 40x90-deg segment of space

INFRARED search system developed by ACF's Avion Div. for ARDC's Cambridge, Mass., Research Center scans 40x90-deg segment of space for its target. It uses a matrix of 30 lead sulphide cells that are scanned electromechanically. The output of each cell is stored in a separate LC tank circuit that "rings" when its corresponding cell is energized. A mechanical commutator samples the outputs of the tank, feeding any signals to a single amplifier—the only one used for all 30 cells.

Device is named Codes (for *Co*mmutating *De*tection *S*ystem) and weighs 15 lb.

THE ULTIMATE IN IR search systems would be an electronically scanned IR vidicon. GE and Westinghouse both have active projects to develop one.

Westinghouse calls its tube the "infratron", and recently announced a developmental prototype had been built.

•

BARRIER GRID storage tube able to resolve 800-1200 TV lines at 75 per cent contrast has been developed by ITT Labs for Army Signal Corps. Just one beam is used for both reading and writing. Focusing and deflection are electrostatic. The beam impinges on a spherically curved target.

Principal uses, says ITT, are in radar and infrared MTI and in binary digital data storage and processing. The tube has two unique properties:

- If a pattern of repetitive signals is applied to the target in synchronism with the scanning electron beam, no signal appears on the tube's output after a few cycles.
- If a signal from a moving target is mixed with repetitive signals from the background, only the moving target information appears in the output.

HEIGHT-FINDING radar will be developed by Maxson for FAA under $1.7 million contract. The system has the unique feature of being entirely passive—it picks up echoes from signals sent out by air traffic surveillance radars.

Returns from aircraft are picked up by a 150-ft-high triangular-prism antenna and fed to the system's own radar receiver. A companion computer will accept information from the receiver together with azimuth data from the air traffic control radar and determine the approximate angle of the echo path and convert it to altitude of target aircraft.

Maxson height-finding radar is entirely passive

MAXSON'S ANTENNA works somewhat like a stacked-beam passive array. Vertically stacked horns divide its vertical coverage volume into 100 segments. The horns apparently will mount vertically along each of the three vertical corners of the prism. Each corner covers a 120-deg azimuth sector of sky.

Maxson did the basic development work for this type of antenna on a classified military electroscan project.

■

INTEGRATED ELECTRONICS logic element built by RCA Labs is made of a 0.000016-in. cube of silicon. Up to 100 million such elements could be crammed into one cubic foot.

FIFTEEN-MEGAWATT (peak) developmental L-band klystron was tested successfully by GE. The company claims the tube is one of the most

more on page 116

through the temperature barrier

Heinemann Type AM Circuit Breaker. Incorporates vibration and shock resistant construction. Available in odd ratings or fractional ratings, instantaneous trip or a selection of time delay characteristics.

you have the added protection of Heinemann Circuit Breakers

One *outstanding* and *exclusive* fact explains why HEINEMANN alone qualifies for protection of critical airborne equipment: The current rating of a HEINEMANN circuit breaker is *not* affected by ambient temperature.

The current rating of a HEINEMANN circuit breaker is always the same . . . whether on a hot tropic field or aloft at a cold 40,000 feet.

In addition, HEINEMANN circuit breakers provide a self-adjusting time delay . . . delay is longer when cold, shorter when warm. No other circuit or equipment protective device can match this performance.

There are many other advantages which are exclusive with the HEINEMANN circuit breaker. Send for your copy of the *"Heinemann Circuit Breaker Engineering Guide."* Just request Bulletin 201.

HEINEMANN *Circuit breakers*

HEINEMANN ELECTRIC COMPANY
170 PLUM ST., TRENTON 2, N. J.

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powerful klystrons ever factory-produced for radar service. Average power is 22.5 kw.

THERMOELECTRIC generators with 35 per cent efficiencies can be expected in the "foreseeable future," opines Dr. Clarence Zerer, director of Westinghouse Research Labs. Zener foresees a three-stage system of three generators in cascade. Each would be of a different material. Input temperature would be 3500 deg F., output would be room temperature.

Waste heat discharge from one stage would be made to flow to the stage ahead. Use of the three generators in cascade would make the overall efficiency greater than that of any single stage.

GE is turning out four packaged voltage-tunable magnetrons

VOLTAGE-TUNABLE magnetrons are in production at General Electric. Four packaged versions, consisting of VTM, cavity, and magnet in one integral unit, are being made. VTM frequency output is essentially a linear function of anode voltage. Power response can be made quite flat over nearly an octave (2:1 frequency range).

•

MOON BOUNCE Maryland-Hawaii communications system for BuShips has Development Engineering, of Leesburg, Va., as prime contractor and Continental Electronics, of Dallas, Texas; Eitel-McCullough; General Bronze; ITT Labs; and D. S. Kennedy as subcontractors. Work on the $4.5 million project has been going on for over a year; the system is now in the final test phase.

TEAMWORK BY GE'S Ordnance and Light Military Electronics Departments is cranking out Polaris guidance and armament control subsystems to Navy's accelerated delivery requirements. According to general manager H. F. Konig, LMED has received over $23 million of Polaris business, most recently a $2.5 million follow-on order from GE Ordnance.

LMED'S POLARIS contracts include both the missile-borne and the submarine-borne computers. The latter keeps a constant fix on both target and sub position, plots the ballistic trajectory between the two, and solves pre-launch fire control problems.

The computer that goes up in the bird is an advanced digital differential analyzer designed by MIT. One of the ways shock resistance and reliability problems have been handled in the solid-state unit is encapsulation of the logic and shift register circuits into plug-in assemblies that are then dip-soldered onto universal printed wiring boards. Circuit designs are checking out well under 50-G rocket sled shocking.

INFRARED light beams and a highly sensitive detector form the heart of a new type of optical alignment device for inertial guidance or other azimuth reference systems. Developed by Chance Vought Opal (*O*ptical *P*latform *A*lignment *L*inkage) generates its own reference axis, eliminating the effect of relative motion as an alignment error source. According to C-V scientist G. Cocharo, who developed it, Opal can get accuracies up to three seconds of arc.

OPAL'S transmission source emits two infrared beams — one non-polarized, divergent, conical, and "coarse"; the other narrow, polarized, and "fine". A phototelescope responds to both.

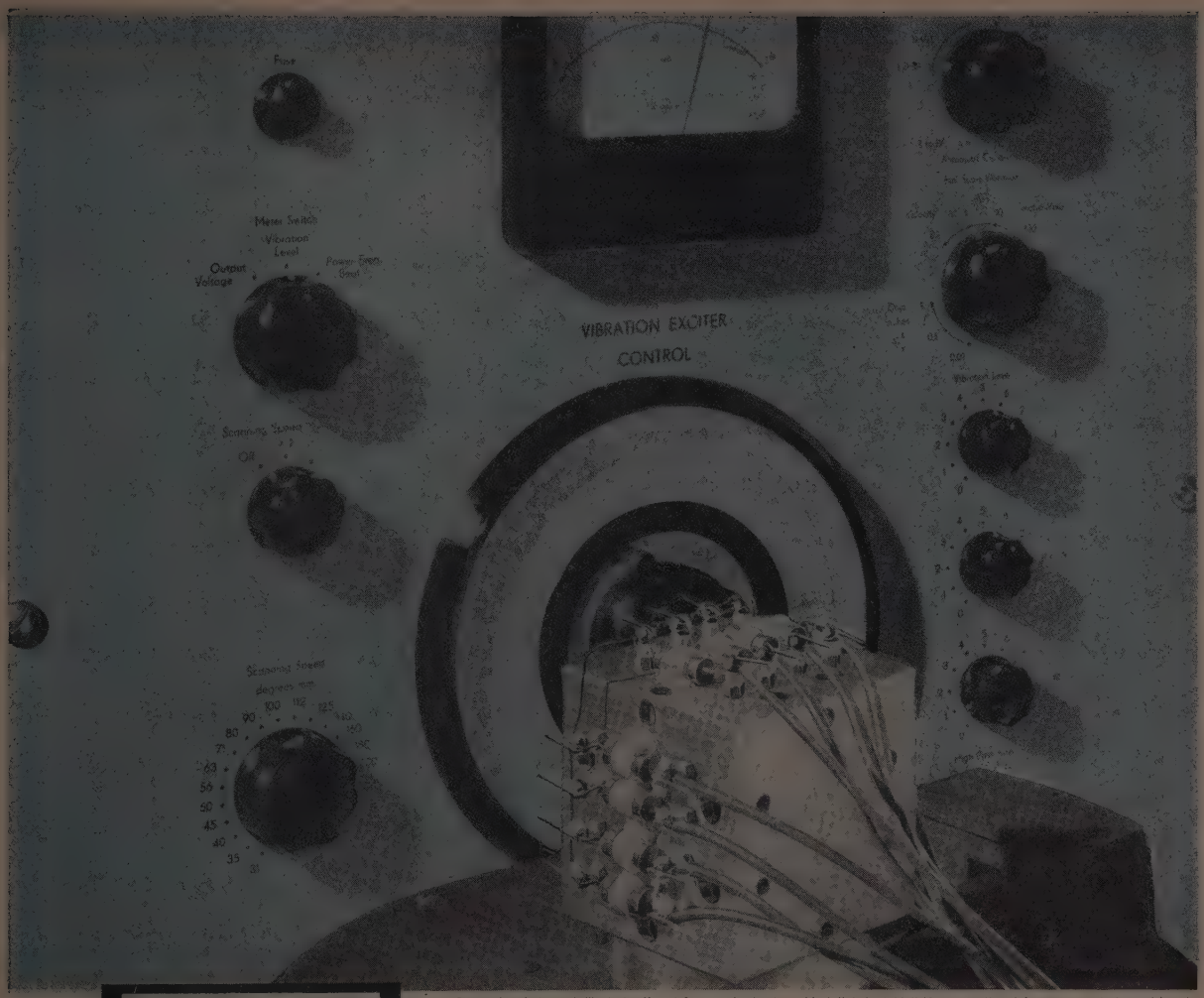
Coarse-beam signals are used to servo-control the source in both azimuth and elevation to focus the beams on the detector. Fine-beam signals are used to align the scope precisely parallel to the fine beam's axis. Optical parallelism information, contained on the polarized, collimated fine beam, can be maintained over a large optical field, allowing compensation for position displacements as well as angular rotations.

Overseas air defense system to coordinate air weapons, communications, radar

UNIVERSAL air weapons control system for air defense outside of continental U.S. is being developed by an industry team managed by GE's Heavy Military Electronics Div. Project 212L covers both fixed and mobile uses. Like the Sage system in the U.S., the 212L system will coordinate defensive radars, communications, and air weapons.

According to GE HMED, the system could be used to defend a single airfield or—with several control sites linked together—could provide air control for an area the size of Alaska or Korea. By linking even more systems together, it could furnish air control over an entire continent.

GE HMED will make the data processing and display systems for the system.



Composite photograph illustrates Kemet Company's aluminum block "shake table" (foreground) and frequency control panel (rear).

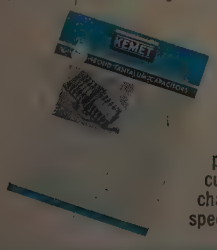
KEMET TRADE-MARK CAPACITORS WITHSTAND SEVERE VIBRATION TESTS WITHOUT FAILURE!

In addition to severe tests involving low and high temperatures, high humidity, electrical overload and salt spray, "Kemet" solid tantalum capacitors are regularly subjected to rigid vibration tests on a routine sampling basis.

During these tests, which are a part of MIL-C-3965B, the frequency is automatically scanned from 10 to 2000 cycles and back in twenty minutes and the capacitors are subjected to twenty-four such cycles; twelve in each of two perpendicular planes. Acceleration and displacement are automatically controlled during each portion of the test. The electrical leads shown in the photograph provide continuous automatic monitoring for open, short and intermittent circuits in the capacitors on test.

In addition to excellent performance on the standard 15g test, "Kemet" solid tantalum capacitors have withstood 45g acceleration on similar vibration tests.

Kemet Company — supplier of a complete line of solid tantalum capacitors — is not dependent on other suppliers for the mining or processing of tantalum. Kemet Company maintains a complete environmental laboratory which includes vibration testing equipment.



Write today for FREE
"ELECTRONICS PRODUCTS ENGINEERING BULLETIN"
This four-page folder provides performance curves, operating characteristics and specifications.

KEMET COMPANY

DIVISION OF UNION CARBIDE CORPORATION

OFFICES: 11901 Madison Avenue, Cleveland 1, Ohio

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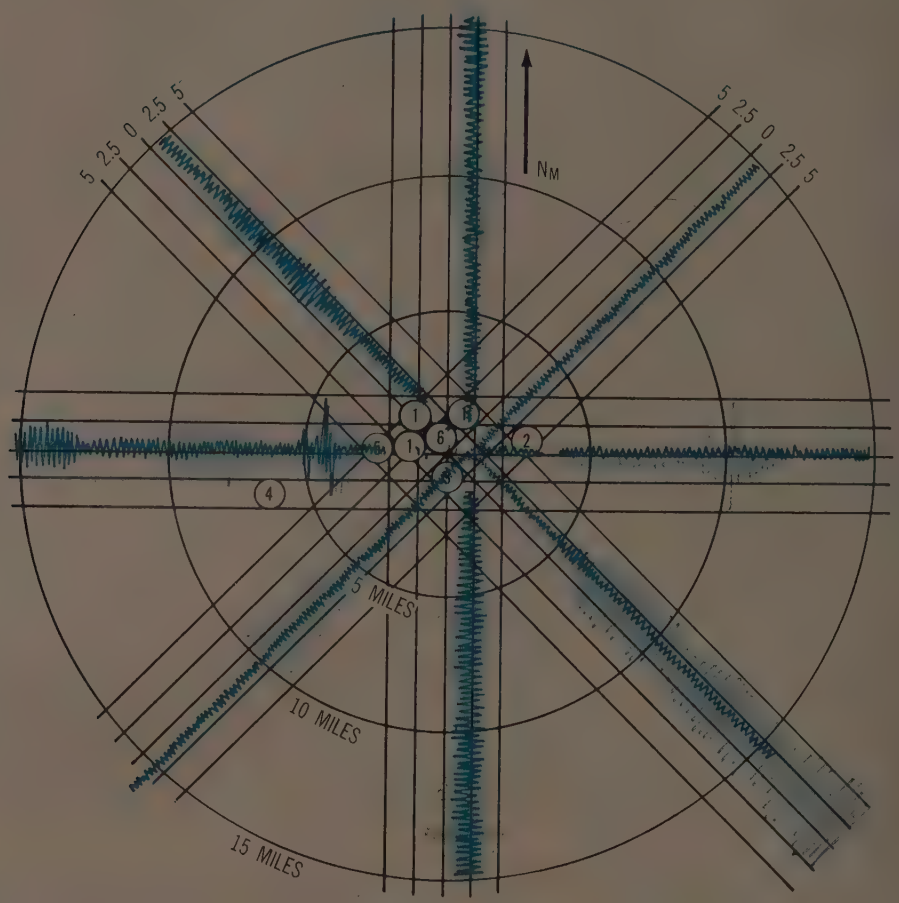


Doppler VOR

extends use of omniranges

The most widely used navaid the world over is the visual VHF omnirange. Its Achilles heel has always been its vulnerability to site errors, for which many cures have been attempted. Doppler VOR is one of them—and there's strong evidence, including flight test data, that it works.

by James Holahan, Electronics Editor

SITE ERROR, the most serious limitation of visual omnirange (VOR) stations, can now be overcome, The Federal Aviation Agency (FAA) reports that in extensive lab field, and flight tests made over a two-year period by its technical Development Center, a "new," Doppler-type of VOR station has cut site error to negligible proportions.

FAA already has tested Doppler VOR at seven installations,* four of which have Doppler VOR on a permanent basis. It is considering the system as a cure for errors at difficult sites now in service—of the 712

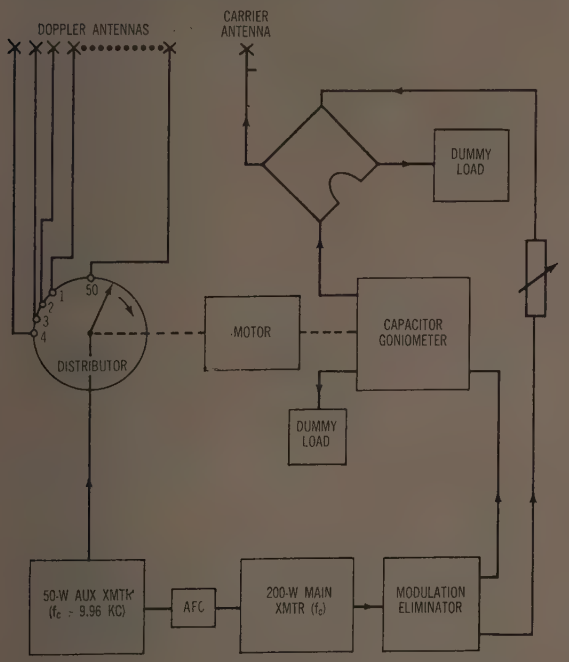
*Charleston, S.C., Daytona Beach, Fla., Hermosa Beach, Calif., Florence , S.C., Jackson, Mich., Indianapolis, Ind., and Riker's Island, N.Y.

Site Error Parameters*

Ratio of Interfering to Direct Signal Amplitudes	RMS Value of Maximum Possible Site Errors (deg)			
	A = λ/4	A = 2λ	A = 5λ	A = 10λ
0.2	7.68	0.59	0.1	0.03
0.5	23.8	1.66	0.2	0.09
0.8	39.7	3.1	0.2	0.17

*Adapted from U. of Illinois Technical Report No. 8 ('48). Aperture is the diameter of the antenna circle. Data are rounded off for all apertures, except for 5λ, for which they are interpolated.

◀ **FLIGHT CHECKS** made with portable Doppler (solid color) and conventional VOR ground stations at Riker's Island, near New York City's LaGuardia Field, showed amplitude of course excursions along eight equally spaced radials. Because of roughness caused by obstructions, standard VOR cannot be used at this site. Doppler VOR is now being installed. The main obstructions are: (1) gas tanks, (2) Bronx-Whitestone Bridge, (3) hangars at LaGuardia (below line of sight), (4) Empire State Building, (5) Hell Gate Bridge, (6) water tank.



IN DOPPLER VOR, main transmitter feeds about 200 W at f_c to modulation eliminator, which divides power between carrier and sideband and removes modulation from the sideband output, which is fed to the capacitor goniometer. The goniometer's output and the carrier from the modulation eliminator are mixed in an RF bridge to amplitude-modulate the carrier at 30 per cent with a constant-phase 30-cps voltage. The 50 W transmitter operates at f_c + 9.96 kc. The difference frequency (9.96 kc) has to be closely controlled. Distributor and goniometer are connected to the same shaft and driven by the same motor to synchronize both 30 cps voltages. (This diagram shows not a final design but one that FAA ◀ has used on an operating Doppler VOR facility.)

VOR stations in the U.S., some 65 suffer from serious course roughness, scalloping, course oscillations, and unflyable bends due mainly to site effects. Doppler VOR should figure heavily in the FAA's plans for 318 additional VOR stations by 1965. For one thing, Doppler VOR's freedom from site error will give the agency a great deal more leeway in site selection.

Doppler VOR is not really new. It was invented back in 1945 by Paul Hansel, chief engineer at Servo Corp. of America, who proposed it many times to the Air Navigational Development Board and directly to the military. However, at the same time, the VOR-Tacan controversy completely preoccupied our airways system planners, and Doppler VOR was shelved for later consideration.

In late 1957, the CAA, looking at a Doppler direction finder built by Servo Corp. of America, became interested in Doppler VOR. Its Technical Development Center (since taken over by FAA) built stations at Indianapolis, Ind., and Charleston, S. C. Tests at both sites confirmed the error-suppressing qualities predicted for Doppler VOR.

Could have prevented controversy

Today some of the FAA engineers that have worked with the system state that, had Doppler VOR been looked into when first proposed, the VOR-Tacan controversy might have been settled in favor of VOR. They point out that the main advantage of Tacan over VOR, less site error, would have been nullified by the Doppler system.

Doppler VOR is entirely compatible with airborne receiving equipment. The airborne receiver compares the phase difference between two separate audio signals. This difference is translated into aircraft-to-station bearing. Since the same phase difference is transmitted in conventional VOR, it doesn't matter to the airborne equipment whether the information comes from a conventional or a Doppler VOR—so long as it is within the receiver's bandpass.

To understand how Doppler VOR works, let's first review the workings of conventional VOR. The system operates in the 108-118-mc frequency range and derives its bearing information from the phase difference

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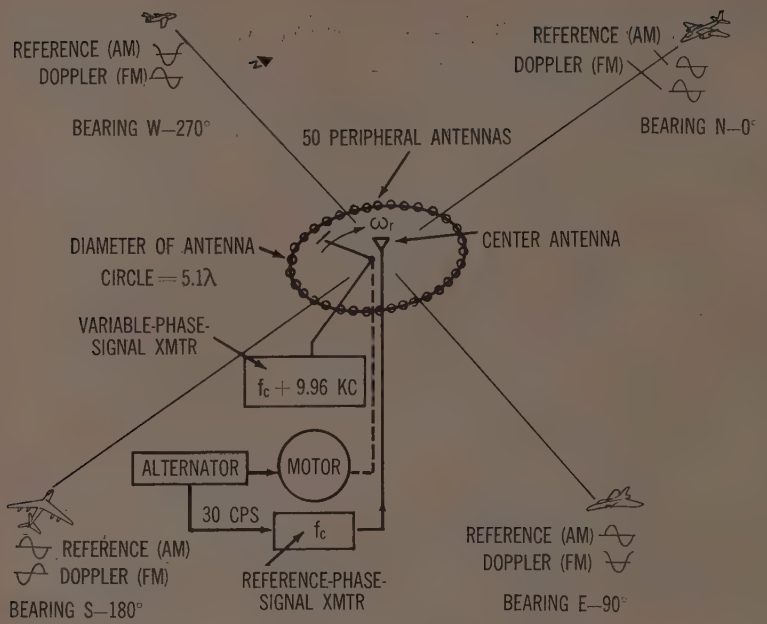


OPERATING principles (left) of Doppler VOR. Below: Radiation at frequency f_o is rotated about X at S rpm and D wavelengths from X. Because of the Doppler effect, the received frequency will be above, below, or equal to f_o depending on whether antenna is moving toward, away from, or at right angles to a line to the receiver.

between two audio signals—a reference phase signal and a variable phase signal. The reference phase is constant (at any instant of time) over a 360-deg aircraft-to-station bearing, and the variable phase varies from zero to 360 deg with the azimuth. Both phase signals are synchronized so that the airborne receiver can measure the difference between them.

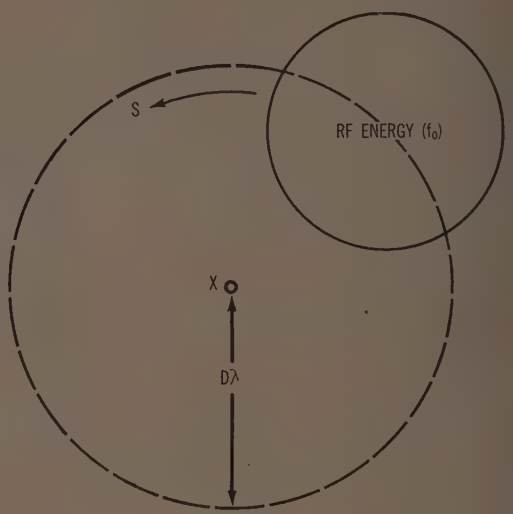
A conventional VOR station has five antennas—four at the corners and one in the center of a square. The center antenna radiates a complex signal in an omnidirectional pattern. This signal consists of the carrier (f_o), which is amplitude-modulated by a 9.96 kc subcarrier—which in turn is periodically frequency-modulated $\pm$ 480 cps from its center frequency at a 30-cps rate. The reference phase is the phase of the 30-cps frequency modulation.

Doppler VOR reverses modulations

The four corner antennas simply radiate the unmodulated carrier in a figure eight pattern. This pattern is rotated at a 30-cps rate by a capacitative goniometer interposed between the transmitter output and the four antennas. The rotating pattern effectively amplitude-modulates the carrier at its rotational frequency (30 cps). The signal voltage detected by an observer at a fixed point in space varies sinuscially as a result of the rotation. The phase of the signal detected at any instant of time depends on the angle between a line from the center of the figure eight pattern to the detector and a reference line (say, magnetic north).

Reference- and variable-phase signals are synchronized because the same source is used for both. A 30-cps generator controls the frequency modulation of the subcarrier in the reference channel; the same 30-cps signal controls the rotation of a synchronous motor that spins the goniometer in the variable channel.

In Doppler VOR, the roles of the frequency and amplitude modulations are reversed (see *Diagram*). The simple signal is radiated from the center antenna and



consists of the carrier directly amplitude-modulated by 30 cps. Reference information is contained in the phase of the amplitude modulation.

The variable phase signal consists of a carrier that is 9.96 kc higher than the one radiated from the center antenna. Instead of using four corner antennas, Doppler VOR uses an array of 50 antennas equally spaced about the circumference of a 22-ft-diameter circle. A motor-driven distributor with capacitor coupling feeds RF energy to each of these antennas 30 times each second.

The second carrier ($f + 9.96$ kc) is frequency-modulated at 30 cps because of the Doppler effect produced by the rotating source of RF energy. This source can be likened to a single antenna whirling in a fixed circular path at 1800 rpm.

If the antenna (see *Diagram*) radiating energy of frequency f_o is rotated about a point X at S rpm and located D wavelengths from X, the received frequency

will be above or below f_o, depending on whether, as the antenna rotates, it moves toward, away from or at right angles to a line to the receiver. The resultant frequency deviation is proportional to the products $D \times S$. Since S is fixed at 30 cps. to produce the necessary 480-cps deviation (*as in conventional VOR*), D is made approximately 2.5 wave lengths 22-ft at the mean VOR frequency of 115 mc).

At the airborne receiver, the reference carrier (f_c) is detected directly. The reference and the variable carriers beat with each other and the receiver extracts the 9.96-kc difference signal with its Doppler-produced variable phase data. The modulation of the carrier by the subcarrier is set for 30 per cent by adjusting the ratio of powers transmitted from the fixed and rotating antennas. Together they form a full-carrier, single-sideband system since only the upper sideband (f_c + 9.96 kc) is used.

During a complete cycle, the frequency will change from f_o to f_o + 480 cps, to f_o, and to f_o — 480 cps. Any reference point in the frequency deviation cycle thus varies as a function of azimuth and consequently so does the phase of the 30-cps component of the subcarrier.

Both reference and variable signals are synchronized through the 30-cps audio signal. This signal is also used for amplitude-modulating f_c and for driving the commutator that energizes the variable array.

The basic design rule for Doppler VOR, according to Hansel, is that the antenna aperture, or diameter of the antenna circle, be close to 5.1 wavelengths. He derives this value from the equation for determining the Doppler shift:

$$\Delta F = (f_c\ \omega_r\ R)/c,$$

where ΔF is the Doppler shift (in cps); f_c, the carrier frequency (in cps); ω_r equals 2π S, with S the scanning rate (in rps); R is the radius of the circle; and c, the velocity of light. The equation may be rewrtten as:

$$\Delta F = \pi\ DS,$$

where D is the aperture, or diameter, of the antenna (in wavelengths). Using the VOR parameters of 480 for ΔF and 30 for S, we get:

$$D = 480/30\pi = 5.1 \text{ wavelengths.}$$

For the VOR (108-118 mc), therefore, the antenna apertures should be around 43-45 ft. With these apertures, bearing errors and course perturbations—commonly referred to as site error—multipath error, and course scalloping are negligibly small compared to the instrumental errors of high-grade VOR-type receiving and indicating system (see *Table*).

Switch of variable voltage helps

The reduced susceptibility to course deterioration from obstacles and terrain relatively close to the ground station is due to the fact that the variable voltage is now contained in frequency modulations of the subcarrier instead of in amplitude modulations of the carrier. As a staff study by the Navigational Aids Engineering Div. of FAA's Bureau of Facilities puts it, "For bearing error (at the receiving point) to exist there must be a combination of right bearing (direct) information with wrong bearing (reflected or re-radiated) information. For the latter, the frequency deviation cycle is displaced in time from that of the former. If a reflected voltage, shifted 90 deg in phase of deviation cycle and having an amplitude of one-twentieth [of] the direct voltage, is added to the direct voltage, it would have little or no effect on the instantaneous frequency of the main voltage. This [effect] has been previously experienced in communications transmission on interfering FM transmissions wherein the stronger signal takes over, and is known as 'FM capture effect.'

"The antenna aperture is related to this effect in that with greater aperture, the overriding of unwanted signals is greater, since the FM deviation is also greater. By comparison, the effect of reflections on the four-loop VOR system using a rotating figure eight pattern is quite large. With direct and reflected voltages as indicated above, the resultant would be the vector sum of the two. Hence the tangent of the error angle would be 1/20, of 0.05, corresponding to an error of about three degrees."

The overall bearing accuracy predicted by Hansel for Doppler VOR is 0.2 deg. Final system accuracy, he points out, then will largely be a function of the airborne receiving equipment.

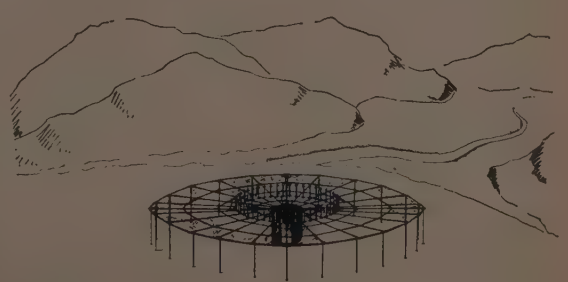
Two of the main problems still being worked on by the system's developers and FAA are:

- 30-cps amplitude modulation on the 9.96 kc subcarrier;
- Doppler VOR's range, which is about five per cent smaller than that of conventional VOR.

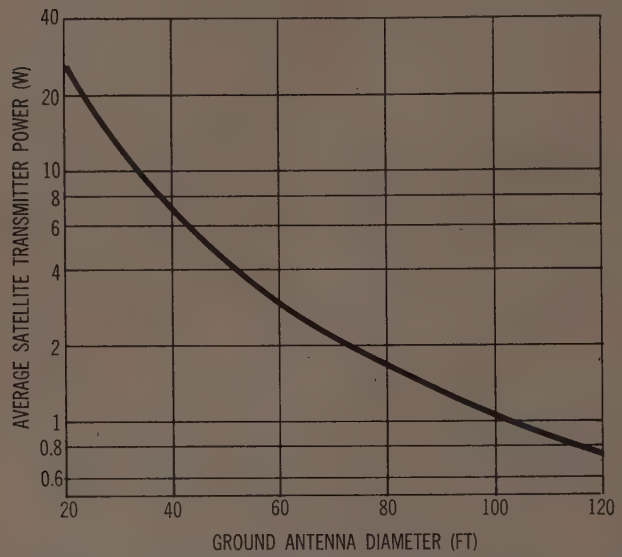
Neither problem would keep the system from being used and doing a better job than conventional VOR at difficult sites. The amplitude modulation problem effects each type of receiver differently. It will not produce errors if the signal level is above the threshold of limiting if the limiter is performing normally. It could, however, produce bearing errors at extreme ranges, at which signal levels are low (especially for insensitive receivers). A good deal of effort is being directed at minimizing this unwanted modulation.

The five per cent lower range is caused by the fact that a larger counterpoise is needed with Doppler VOR. (150 ft as against 45 ft with conventional VOR). It steers the radiated beam up, shortening its horizontal component. Servo Corp. of America is working on a new type of antenna that, it says will give even greater range than conventional VOR. The trick, it appears, is getting the needed horizontal polarization (VORs radiate horizontally polarized energy) with a much lower lobe.—End

Reference—P. C. Sandretto, "Electronic Avigation Engineering;" ITT. "Performance of Doppler VOR at Difficult Sites," Navigation Aids Engineering Div., Bureau of Facilities, FAA. P. Hansel, "Doppler Effect Omnirange," *Proc. IRE* Dec. '53.



DOPPLER VOR station arrangement.



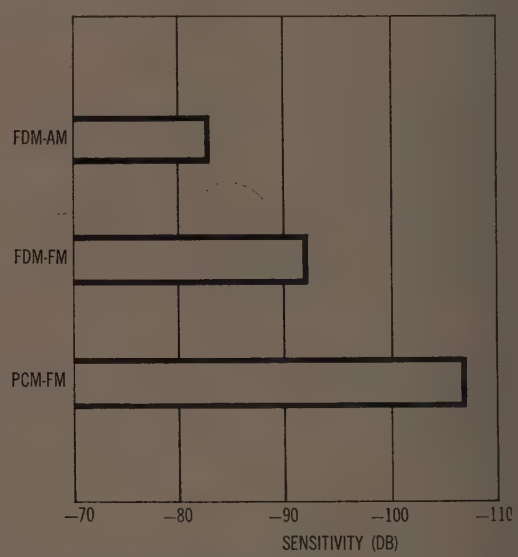


FIGURE 1: Satellite transmitter power vs ground antenna diameter (left, for 96 voice channels, two-kc carrier, -107 db ground receiver sensitivity, 25 deg satellite antenna BW). Right: Ground receiver sensitivity of several modulation techniques (for 40 db S/N, BW for 12 three-kc channels, one decibel NF, 40 deg K antenna temperature).

What the designer faces in active

satellite communications

Even for global microwave communications, it's hard to think of a more ambitious scheme than a 24-hour-orbit active satellite system. The question is, Can we meet the requirements of such a system? Here is an analysis—and an optimistic one—of the critical problems involved.

THE FIRST space vehicles to be put to "practical" use will be earth satellites serving as microwave links for global communications, predicts D. M. Culler, associate director of the Astrionics Lab at ITT-Fort Wayne (Ind.). Participating in the EIA Technical Symposium on Aircraft and Space Communications at the recent World Congress of Flight, in Las Vegas, Nev.

We're faced, he noted, with a great need for broadband microwave coverage over large water masses, which rule out conventional microwave links. In voice and teletype communications alone, it's estimated, there will be seven times more overseas messages in 1970 than there were in 1950. To take advantage of high data transmission rates for vast, world-wide control system functions would also call for a global microwave repeater system to provide sufficient broadband capability.

There are four classes of communications satellite systems—low altitude passive and active and 24-hour-orbit passive and active. In the passive case, the satellite acts merely as a reflector of the transmitted energy; in the active case, it acts as a translator or transponder.

Studies show that the active 24-hour satellite system may be best in the long run, Culler revealed. It's range and power requirements are within the state of the art of ground equipment, background noise interference is

minimized, and the system could serve as a relay to other space vehicles.

Figure 3 outlines the basic concept of the 24-hour-orbit system. Essentially, there are three satellites with active repeaters orbiting in the equatorial plane at an altitude of 22,300 miles and rotating about the earth at precisely the earth's own spin rate. With one of the satellites stationed every 120 deg about the orbit and using three ground relay stations in the line-of-sight overlap areas, you get almost complete (98 per cent) global coverage with line-of-sight communications. (To get full coverage, you'd have to add satellites in polar orbits or planes inclined to the equator.) Note that the angle subtended by the two tangents to the earth's circumference from the satellite is about 17 deg. We therefore need an antenna beamwidth of at least 17 deg, said Culler.

Table I lists some of the most important system design problems. Two very significant ones, from an overall standpoint, are life and reliability. If the system is to be economically feasible, the satellite must operate continuously for at least 1-2 years.

No maintenance can be performed

Actually, the functional life of the satellite depends on (1) state-of-the-art component life (primarily of the electronic components) and (2) the supply of control propellants the satellite can carry and use to keep it on station and at the proper altitude. The major limitation is that the satellite equipment, once operational, has no chance of maintenance.

The frequencies available for the communications system are limited by atmospheric attenuation and ionospheric reflection. A usable range might be 1000-10,000 mc, Culler suggested. The system's information-handling capacity primarily depends on how much of the satellite payload weight can be used for the repeater and its power supply. Of course, modulation techniques and noise levels also affect this capacity.

The state of the art in rocket design restricts the payload that can be put into a 24-hour orbit. So it's

more on next page

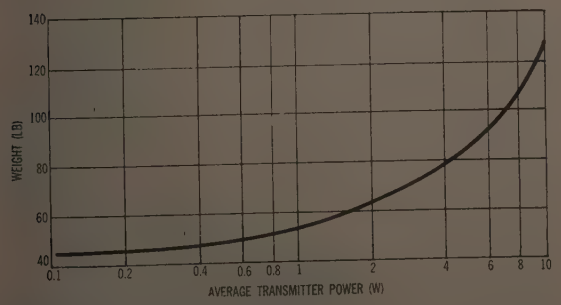


FIGURE 2: Estimated satellite weight (including power supply) vs transmitted power.

Table I: Major System Design Problems

Parameter	Limitations	System Requirements
Life	Component state of the art, control propellant supply	1-2 years minimum
Reliability	no satellite maintenance	no satellite failure, redundancy
Communication Subsystem		
(1) Coverage	line-of-sight with 3 Satellites—98%	depend on application
(2) Frequency	ionosphere effects, atmosphere effects	1000-10,000 mc
(3) Capacity	weight, bandwidth, power, modulation	voice, teletype, TV
(4) Satellite Transmitter Power	weight, electric power supply	directional antenna, high power efficiency
(5) Ground receiver sensitivity	noise, S/N ratio, modulation technique	high antenna gain, parametric amplifiers
Vehicle subsystem		
(1) Payload	rocketry state of art	V=10,070 fps, h=22,300 miles
(2) Ascent guidance & control	multiple orbits, planar transfer, guidance blackout	$\Delta V = \pm 5$ ft/sec $\Delta\alpha = \pm 0.1°$
(3) Orbit guidance & control	moon-sun gravitation, light pressure, dumbbell effect, internal moments, antenna beamwidth	±0.1° latitude & longitude, ±4° attitude control
Electric power subsystem	Weight, surface area, solar collector state-of-art	Max energy conversion efficiency

best to build up the ground receiver sensitivity to minimize the power needs. Ground receiver sensitivity then in a sense is an independent variable in the system design. Its limitations are a function of receiver and space noise, modulation technique, and the S/N ratio needed for clear communication.

NFs of 0.5-1.5 db can be achieved

Using parametric amplifiers, you can get receiver noise figures in the region of 0.5-1.5 db. Also, improved modulation techniques allow efficient use of these noise figures at high channel S/N ratios, making it possible to attain both high sensitivity and signal quality in the ground receiver at the present state of the art.

The required satellite transmitter power output is a function of path loss and ground station sensitivity. Since the power output is limited by the payload weight and the electric power supply, the maximum communication capacity of the system is a function of the minimum power level detected by, or the maximum sensitivity of the ground station, and the maximum power output of the satellite transmitter.

The limit on satellite gross payload is a major factor in the system design. A 400-lb satellite in a 24-hour orbit at a velocity of 10,070 fps and an altitude of 22,300 miles is within reach today. The ascent and guidance phase will probably involve multiple orbits in order to set up a minimum energy trajectory.

If the satellite is not launched from an equatorial site, at some point during the ascent trajectory there must be a planar transfer from the inclined plane of launch to the equatorial plane. This requirement, Culler noted, places a critical burden on the guidance. Also, since radio command will probably be used for the multiple-stage functions the possibility must be considered that the vehicle will be temporarily out of the line of sight of the ground command station(s). Model trajectories show that the ascent guidance and control must control the velocity amplitude within ± 5 fps and the flight path angle within ± 0.1 deg.

Table II: Weight Breakdown for 400-Lb-Class Satellite

Subsystem	Weight (per cent)
Communication equipment	12
Control equipment incl. propellant	23
Electrical power supply	39
Structures	26

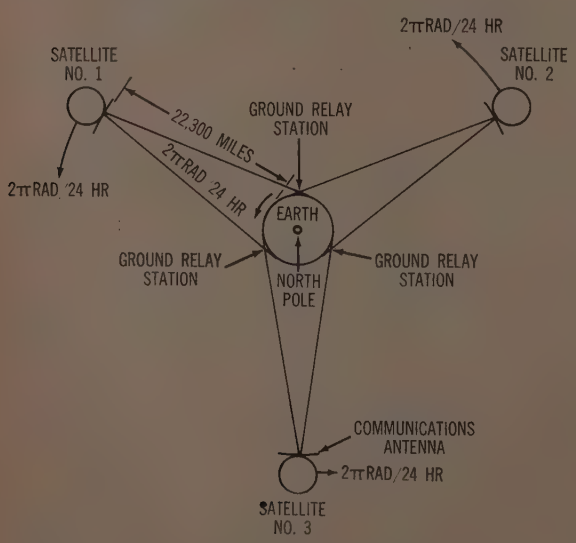


FIGURE 3: Three-satellite system geometry.

Antenna limits attitude control

Once the satellite is in the desired orbit, Culler added, there's the problem of keeping station and proper attitude with the respect to the earth. Here the satellite antenna is a limiting factor. For optimum transmission path gain, it must be directional and of minimum beamwidth, so the vehicle will have to be referenced as closely as possible to the earth's vertical.

Torques and other perturbating forces are problem sources that the designer must watch out for, Culler warned. Against disturbances due to the moon-sun gravitational field, light pressure, and residual drift rate, the position of a satellite can be controlled within about 0.1 deg latitude and longitude. Abainst torques due to light presure, residual magnetism, induced currents, and the "dumb-bell" effect (if these follow our best estimates), attitude could be held to within ± 4 deg of nominal about all three coordinate axes. However, generally we need more data on such forces and torques.

Solar energy to be used for power

The electric power system's requirements are limited by the weight and surface area available in the satellite payload and the efficiency of solar collectors. For the immediate future, the primary source of energy for the satellite will be solar energy, with batteries used during periods when the satellite is in the earth's shadow, Culler stated. Later on, nuclear and other novel sources will be available.

At present, solar cells have an efficiency of about 8-10 per cent, requiring approximately 75 lb and 15-20 ft per 100 W. Within five years we should have electric power sources that will provide four W/lb.

Culler went on to describe the design of the communications subsystem more closely. *Figure 1* shows the minimum acceptable receiver input signal for various types of modulation techniques. PCM-FM offers the highest sensitivity, permitting the reception of an input signal level of about —107 db.

Taking this ground receiver sensitivity of —107 db into account, *Figure 1* also shows the required satellite output. The 25-degree beam width for the satellite antenna is the smallest that will cover the 17-deg angle subtended by the earth and at the same time allow for the ± 4 deg tolerance of the satellite attitude control system. We can also see that average satellite transmitter power-output of three watts is adequate for a 60-ft ground antenna, Culler concluded.

ARTIST'S CONCEPT of 24-hour-orbit active communications satellite about seven foot long and four feet in diameter. Fixing the 16-in. antenna to the satellite frame gives maximum reliability by eliminating antenna tracking mechanisms. Because of solar cells on the cylinder's periphery, no special array and orientation are needed. Small jets are for position and attitude control. Attitude reference comes from infrared horizon sensor.

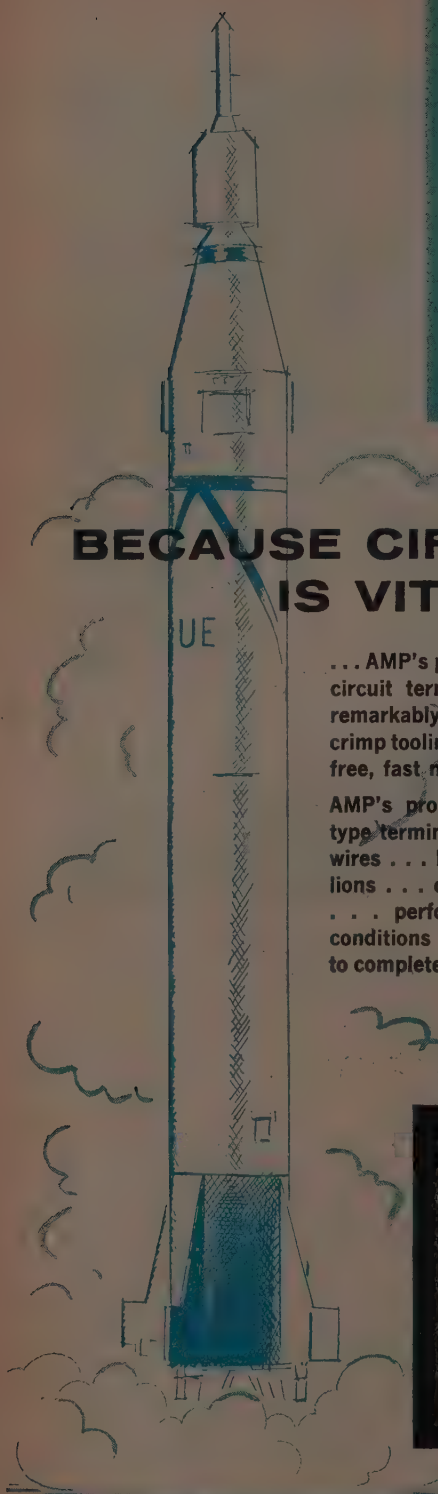
Figure 2 plots the weight of the active satellite repeater equipment and its power supply against power output. For example, for three watts average power output, the repeater would weigh approximately 70 lb. For reliability purposes, the repeater components must be proven items. Future satellite equipment might use traveling-wave tubes for broadband amplification, but first TWT power efficiency and reliability have a long way to go beyond the present state of the art.

Power supply system is heaviest

Table II shows that a 400-lb satellite could adequately provide for a communication repeater, orbit guidance and control equipment, and power supply for a 96-voice channel capability. Again the heaviest item is the power supply subsystem, Culler noted. However, gross satellite payloads of 5000 lb may be expected within five years, propulsion experts say, and these would certainly enhance satellite transmitter power output, reliability, and flexibility.

Culler pointed out that communication by satellite is fast becoming competitive with transoceanic cable transmission. Current trans-Atlantic cable costs, he pointed out, are roughly $200 per voice channel mile. A 96-voice channel satellite repeater system that could be put into operation in the immediate future for Atlantic coverage would cost about $300 per voice channel—even if you allow for a two-year satellite life as against a 20-year cable life. A further point made by Culler was that present cable systems cannot handle conventional TV transmission because of the wide bandwidth requirement of 4.5 mc.

Culler cited estimates that a complete global 24-hour active satellite communication system would cost about $100-300 million at the present state of the art. Economically such a system therefore would be feasible for the immediate future, he stated. In view of the expected improvements in the payloads and reliability of rocket vehicles, eventually it probably will become the most economic means of long range broad-band transmission, Culler claimed. A good measure of rocket progress, he said, is given by the cost figures per pound of payload for a low altitude orbit: Only two years ago, the cost was $1,000,000, by 1960 it should be down to $1000, and by 1964 it should be as low as $100.—End



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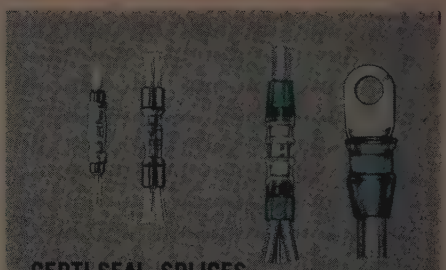

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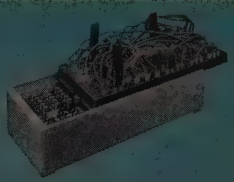

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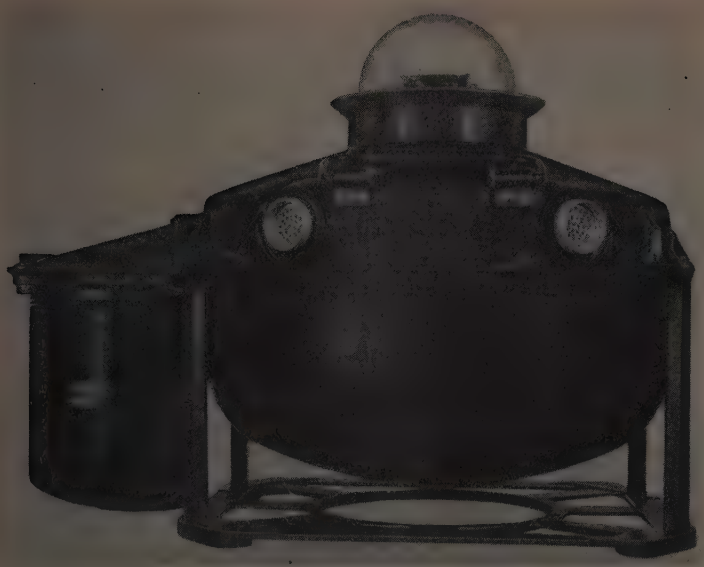
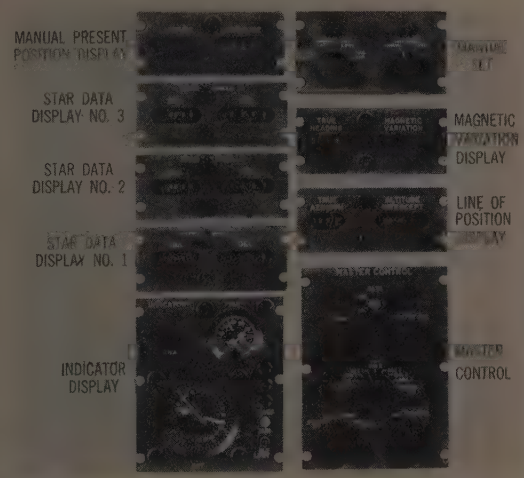
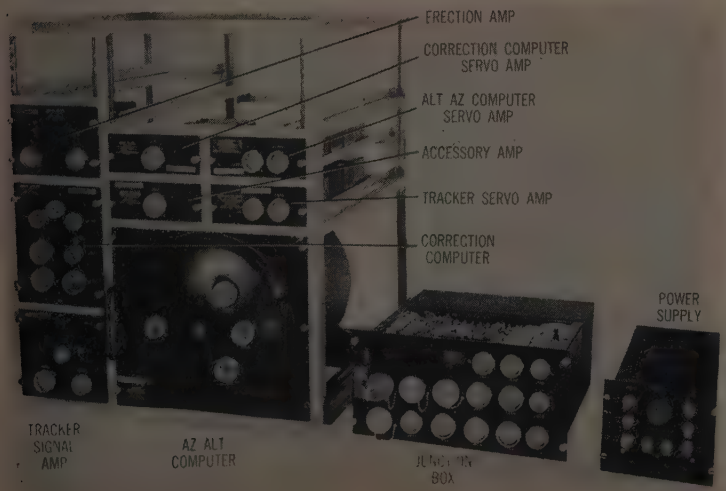


AUTOMATIC tracker is normally mounted against plane's top skin, the two-inch-radius dome protruding. Scope sits in roll and pitch platform, uses attached vertical gyro for horizontal reference.

CONTROLS group (right) as navigator sees it. Present position unit is used if dead-reckoning source is disabled and assumed latitude and longitude are manually set in. Star data boxes store co-ordinates of three stars for fast position-fixing. Below: Computers and electronics. Junction box hooks up with automatic tester for go-no-go system check.





by Bernard Kovit
Associate Electronics Editor

Astro compass brings space navigation closer

AUTOMATIC astro compass developed by Kollsman Instrument Corp., Elmhurst, N.Y., is one of a family of celestial guidance systems well into production under USAF and Navy contracts. With optical method's unchallenged angle measurement accuracy, 150-lb compass measures relative bearing of a star and automatically combines this with azimuth angle computed internally. Difference is vehicle heading relative to north. System gets true heading with only a six-minute RMS error. Mounted on a roll- and pitch-stabilized platform and referenced to a vertical gyro, its photo electric telescope is servo-controlled about relative bearing and altitude axes. Small analog computer is used instead of conventional sextant method of finding azimuth and angle from navigation tables. Compass is used in B-52 as major part of bomb-nav system. Smaller, more advanced version—coupled with an inertial platform—guides Hound Dog air-to-ground missile. Other units are used in Convair B-58, Martin P6M, and in nuclear subs. Circle No. 53 on Reader Service Card for more data.

more on next page

INPUTS

Latitude & Longitude: from external nav computer as one- and 25-speed synchro signals or manually set in system

BATH (Best Available True Heading): external source of one-speed synchro information

SHA (Sidereal hour angle of celestial body): manually set one- and 25-speed synchro information

DEC (Declination of celestial body): manually set one- and 25-speed synchro information

Time (Greenwich Mean Time): from external clock and gear train (time drive from precise, fork-controlled synchronous motor)

OUTPUTS

True Heading: servo-controlled counter readout or one- and 25-speed synchro from external source.

Altitude Intercept: servo-controlled counter readout.

Heading Correction: from external source of 10-speed synchro information or internal servo-controlled counter readout

True Azimuth: Servo-controlled readout

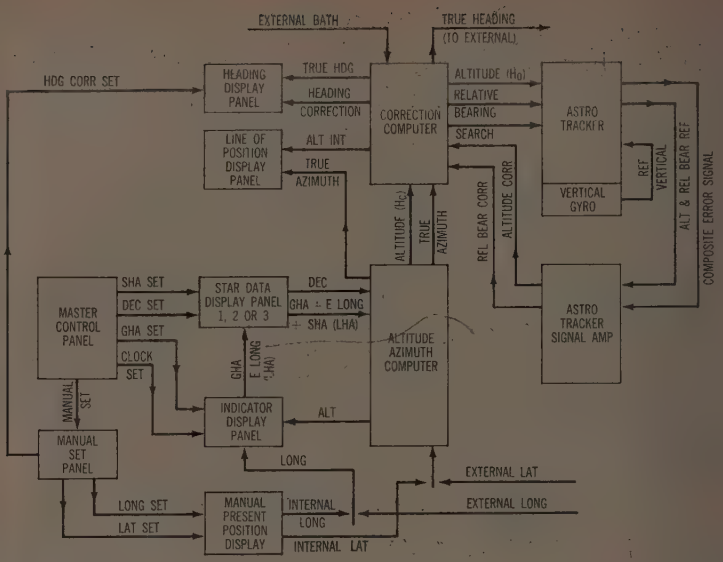
Design & Performance Specs

Power Requirements: dc, 3 amp at 28.5 V; ac, three-phase four-wire, 115/200 V, 380-420 cps

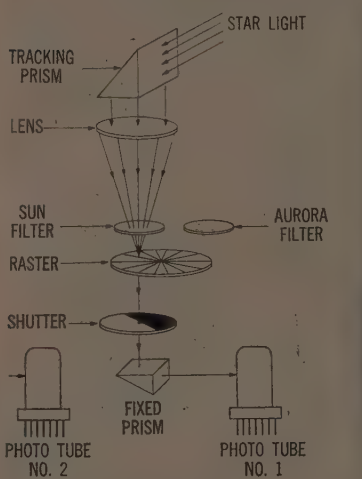
Accuracy: true heading accuracy is six minutes for celestial body altitudes of 10-60 deg, within region of 4-deg roll and pitch; less accurate for star altitudes of 75 deg and up; altitude intercept accuracy is seven minutes with star altitudes of 10-75 deg.

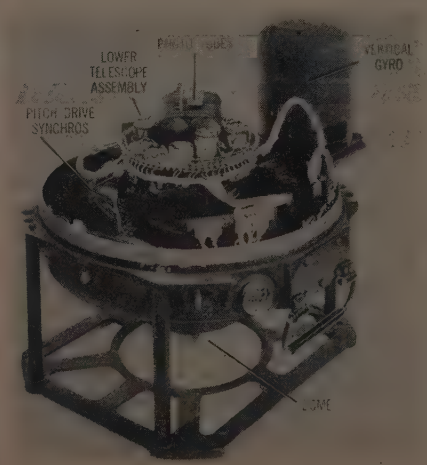
Tracking Sensitivity (sun, planets, stars): sun can be tracked to —4.5 deg altitude; system will track Mars, Jupiter, Venus, and Saturn; about 60 navigational stars can be tracked; Polaris, a third-magnitude star with photoelectric magnitude of 2.5, is taken as threshold, can be tracked with full moon 90 deg away; system will track first-magnitude star with moon 10 deg away

Tracking Sensitivity (twilight): in repeated roof-top tracking tests, system followed first-magnitude stars with sun 5-6 deg below the horizon (twilight limitation is reduced when system is operating at aircraft altitude)

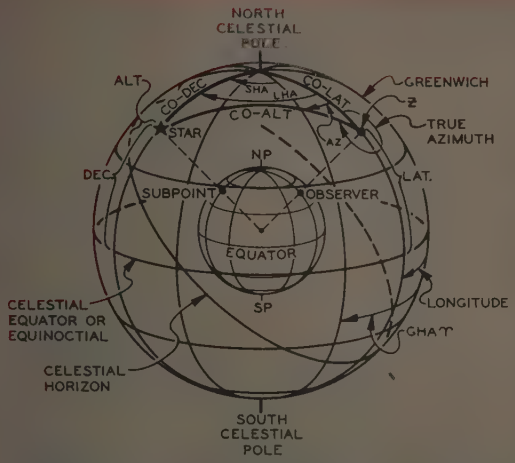


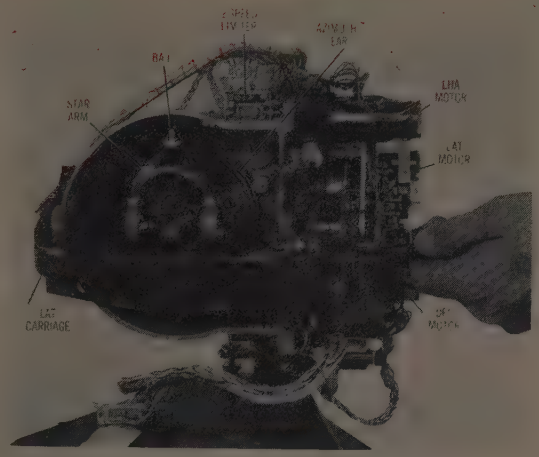
FUNCTIONAL—From initial inputs (left), system computes line of sight to region of selected body. Tracker searches region in a spiral pattern until it locates body. Angular altitude and relative bearing errors between computed and actual LOS are fed back to give altitude intercept and true heading correction, respectively. Corrected LOS puts tracker right on star image in track mode. Corrected BATH yields true heading.



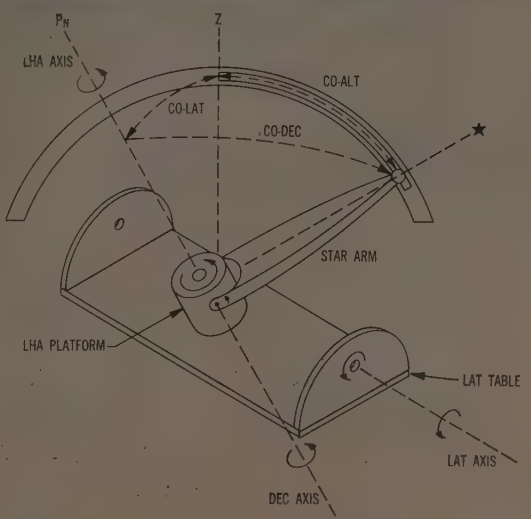


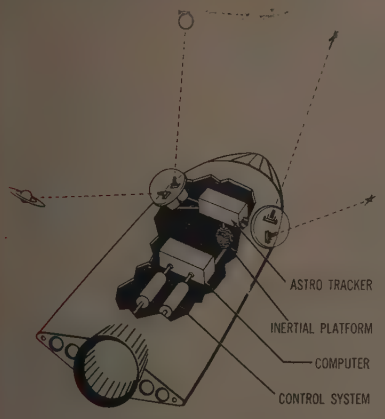
TELESCOPE optics (above) collect, focus star light, modulate it as signal to phototube (PT) that changes it to electric information. Fixed prism rotates to feed second or standby PT. Inverted platform (left) shows dual-PT housing and part of scope drives. Roll and pitch platform keeps scope vertical within platform limits of 15 deg. Since tracker is basically mechanical, it's entirely sealed and filled with dry nitrogen to protect optics, keep mechanics from corroding.



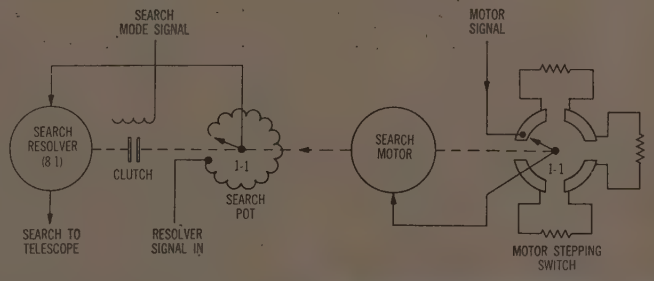


CELESTIAL NAV BRIEFING (above)—True heading determination by celestial reference is basically a method of finding the position of a body in azimuth with respect to celestial and geographic north poles. Position of the two spheres relative to one another is measured as Greenwich hour angle of Aries (GHA ♈), or the latter's westward displacement from the Greenwich meridian. Knowing three points on celestial sphere—observer's zenith (Z), star position (measured in terms of SHA and DEC), and celestial NP—gives you conventional celestial nav triangle, whose known parts are CO-DEC (complement of declination), CO-LAT (complement of latitude), and LHA (westward displacement of body from Z). Solving this triangle gives your body's position with respect to Z in horizontal coordinate system in terms of CO-ALT (body's displacement from Z) and azimuth. In Kollsman compass, an analog computer (photo and right) mechanically reproduces the nav triangle components; gives solution as synchro output.



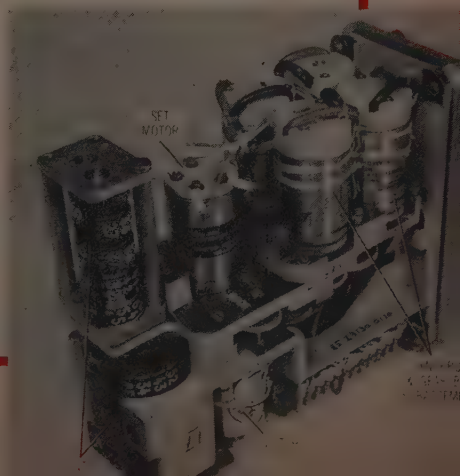


SPACE NAVIGATION scheme studied by Kollsman has vehicle mounting inertial platform, computer, and multiple star tracker. Sun is tracked for vertical. Two stars and a planet give lat and long about sun and range. One star's direction would suffice for steering reference.



SEARCH mechanism—spiral ▲ search pattern is expanding circle developed by driving tracker from output of a rotating synchro resolver connected to a stepping switch.

DESIGN feature is wide use ▶ of interchangeable synchro-and-gear-box subassemblies.



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New! Polyken #292 glass fabric tape with silicon adhesive for use in high-temperature applications such as jet aircraft.

Four new tapes—three thermo-setting, one thermo-plastic—have been added to the Polyken line.

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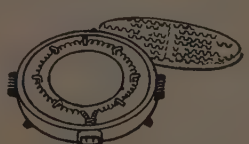
Polyken Sales Division

New! Polyken #158 cotton-backed electrical thermo-setting tape. Used in electric motor construction, etc.

New! Polyken #154 acetate cloth-backed thermo-setting tape, used for small gauge coil winding, etc.



New! Polyken #293 glass cloth-backed electrical thermo-setting tape is used for electrical appliances, etc.

INDUSTRIAL TAPES • PLASTIC FILMS • PROTECTIVE COATINGS

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SEE SYSTEM comprises TWT amplifier and power supply (above) and two antennas (receiving and transmitting). Received ground surveillance radar signals are linearly amplified and returned.

SEE Specs

Type	Frequency (kmc)	Echo Area (m^2)	Power (W)		Weight (lb)	Volume (cu ft)
			In	Out		
L-170	0.9–2	to 5000	60 (ac) 15 (dc)	2 min (RF)	15	0.25
S-178	2–4	to 250	60 (ac) 15 (dc)	1 min (RF)	10	0.25
C-X-176	5–8 8–11	to 15 to 25	30 (ac) 15 (dc)	0.5 min (RF)	10	0.25

Target's radar cross-section controlled with TWT amplifier

Sperry's echo enhancer (SEE) for target drones may be described as a "very remotely" installed final amplifier for surveillance radars. By controlling gain of the amplifier a SEE-equipped drone can be made to look like a Bomarc or a B-52. The device also has potential in countermeasures and in general aviation.

by Henry Prew, Project Engineer
Sperry Gyroscope Co.*

RADAR targets are augmented by artificially increasing the level of the normal radar echo signal from the target. Specifically, the impinging radar signal energy density is increased on re-radiation—by energy focusing, as with passive reflectors, or by actively adding more energy, as with triggered beacons, regenerative oscillators, and linear amplifiers.

With a passive reflector, echo augmentation is bought at the expense of angular coverage. In the active types, almost any desired spatial coverage can be gotten by suitable antenna design.

When target simulation is required (e.g., to make a drone reflect like a specific target or missile) as well as echo enhancement, the reflection area from the target must be constant. Hence the ratio of input to output power density must remain constant despite changes in radar range.

This requirement defines the radar target cross-section parameter of the standard range equation. For a reflector, it infers a constant sized surface; for an amplifier, a constant system gain. A triggered beacon or a regenerative oscillator, whose power output is constant for any signal level above some minimum, therefore cannot be a true cross-sectional area simulator.

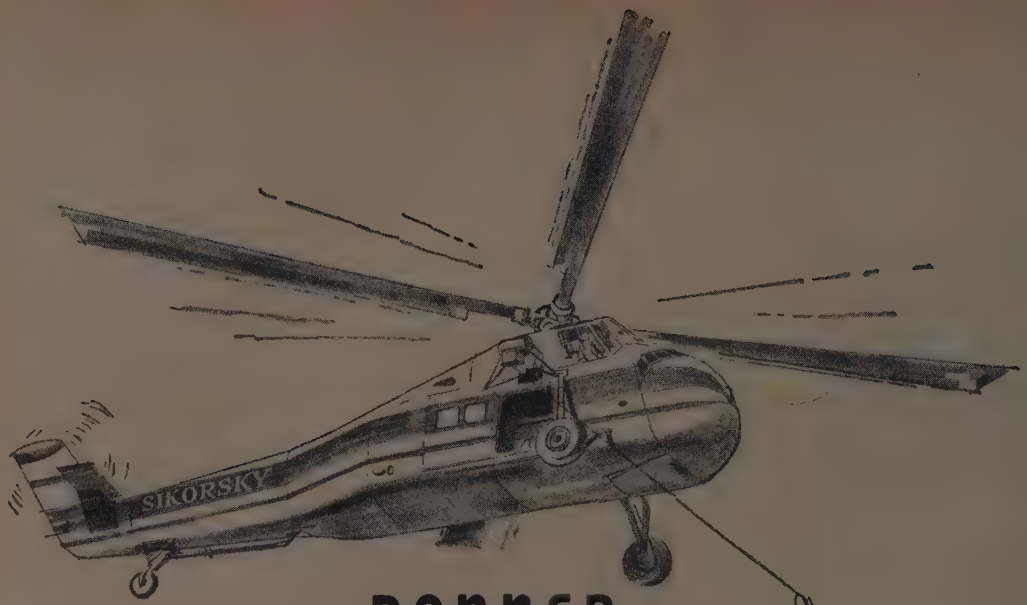
It can be shown that for linear-amplifier-type active augmentation the simulated radar area σ is a function of the net gain of the system (including the gain of the antennas and any system losses) and the operating frequency:

$$\sigma = (\lambda^2/4\pi)G_A,$$

where σ is the operating wavelength in the same terms as the desired

more on next page

*Sperry Gyroscope Co., Great Neck, N.Y.



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Using only a few ounces of force, anybody can walk a helicopter fitted with automatic stabilization equipment using a Donner designed stabilizing coupler. In a more useful vein, the big birds perform vital tasks where the ability to hover precisely and maintain stability is critical. Currently, Donner equipped Sikorskys are used extensively for submarine detection, surveilance, rescue, lifting, and a host of other activities.

Transistorized Model 4310
0.1% linear accelerometer shown 1/2 size.

Heart of the Donner coupler is a small Donner servo accelerometer which measures linear acceleration to at least 0.1% of full scale. The internal servo system offers excellent resolution and linearity. These sturdy reliable instruments are hermetically sealed and magnetically shielded. The entire Donner system weighs less than 25 pounds.

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area and G_A is the net augmentor gain. This equation can be solved for G_A and converted to decimal form to give:

$$G_A\,(db) = -38.5 + 10\log\sigma + 2\log f_{mc},$$

where σ is in square meters.

A linear-amplifier augmentor was put into development at Sperry Gyroscope's Aeronautical Equipment Div., Great Neck, N. Y., in late 1956 and first flight-tested in early 1957. It uses a very wide-band microwave amplifier in the form of a traveling wave tube. The TWT has an adjustable gain characteristic for a definite dynamic range of the input signal level. This range extends from the input noise level to the level that is needed for output power saturation. The TWT is complemented by a power supply and an input-output antenna system that permit optimum operation and provide the desired spatial coverage (see *Table*).

SEE (for *S*perry *E*cho *E*nhancer) was developed to fill a prime need in drone target use for weapon systems evaluation and training—it enables small, expandable drones to exercise weapon system radars, operators, and missiles as if they were actually larger or specific targets.

SEE is made in three basic models

SEE is made in three basic models, covering the L, S, and C-X surveillance, tracking, and missile guidance bands. Its features are:

- true area simulation as a function of net system gain,
- adjustable area simulation in level and spatial distribution through attenuators and antennas,
- bistatic operation for semi-active missile systems,
- simultaneous multiple-frequency operation,
- on-off remote control by command or manual relay operation.

SEE's gain is adjusted to be directly proportional to the desired simulated area. The saturating power level determines the limit of linear operation and so the true area simulation.

Light and rugged TWTs used in SEE

In operation, it is both desirable and possible to match SEE saturation levels with the onset of the non-linear, or saturating, characteristics of AGC or signal limiting in tracking and surveillance radar systems. Here the important augmentation regions are those of detection and lock-on of the radar receivers, where the signal and the receiver noise levels are competing.

These non-linear radar system effects usually come into operation at S/N levels of roughly 7-10 db. These levels then set the criteria for the dynamic range of realistic active augmentors.

The TWTs used in SEE are light-weight, metal-ceramic types of extremely rugged design that use PM focusing. Besides its primary purpose of simulation, the system has potential application in military and civil air traffic control. It may also be used for electronic countermeasure decoys, an application that is now being studied. Presently SEE is in operation at the missile ranges at Eglin and Patrick AFBs, Fla.—End

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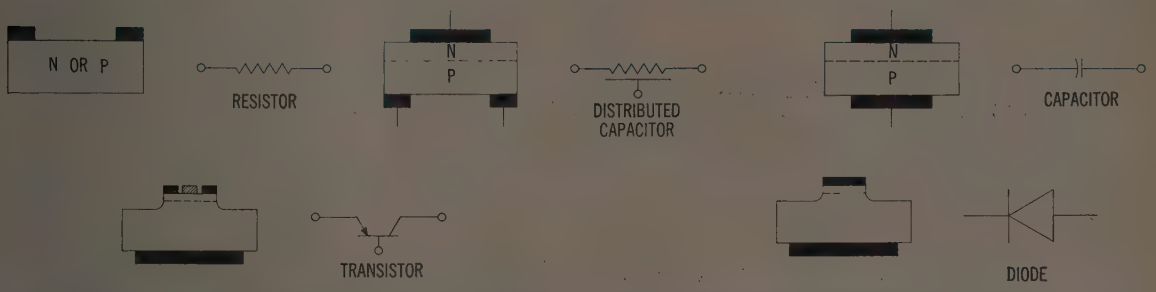

FIGURE 1: Microscopic elements formed from silicon by Texas Instruments, whose masking, etching, and diffusion techniques yield circuits with equivalent densities of up to 34 million parts per cubic foot. Resistor is formed by applying ohmic or non-rectifying contacts to a semiconductor wafer; distributed capacitor, by combining resistive and capacitive elements; capacitor, by using the capacitance of a relatively large area of P-N junction; transistor, by diffused-base transistor techniques; and diode, by diffused-base techniques.

Three pacesetters for tomorrow's aerospace electronics

● Micromodules ● Semiconductor Solid Circuits ● Nuvistors

THREE developments have been announced over the last three months that will undoubtedly be of great importance for future aero/space electronic circuits and equipment:

- progress in the Army Signal Corps-RCA micromodule program to the point where there are now 15 modules available to military contractors from RCA;
- semiconductor solid state circuits, developed by Texas Instruments;
- a new type of electron tube, called the "nuvi$tor" by RCA's Electron Tube Div.

The 15 *micromodules* now available on an engineering sample basis (*Table I*), are the first tangible results of the Army's micromodular

more on next page

THREE experimental nuvistors developed by RCA's Electron Tube Div. and their conventional counterparts (l. to r.): Small signal triode and 6BN4, small signal tetrode and 6CY5, and beam power amplifier and 6DQ6A.

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TEMPERATURE CONTROL EXPERIENCE:

AVIONIC COOLING

Eastern cooling packs for electronic subsystems extend operating ranges to altitudes where air cooling becomes ineffective. 'Black box' designs can be more compact—reliable even at five times the speed of sound.

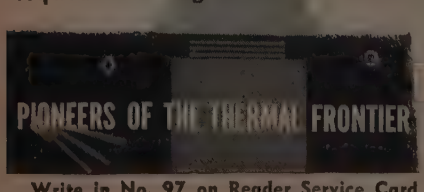
These liquid cooling systems are completely self-contained—provide such components as pumps, heat exchangers, air impellers, reservoir, coolant flow and temperature interlocks and similar parts.

Cooling capacities of existing systems range from 1,000 to 22,000 watts dissipation rates. Eastern cooling packs take ambient temperatures from −55°C to +55°C in stride, and perform to altitudes of 60,000 ft.

Extensive experience in missile applications has enabled Eastern to develop systems unusually compact and light as well as highly reliable. At the same time, Eastern is able to provide at minimum cost equipment engineered to a specific need by using missile-proved components designed to your system configuration.

Turn to Eastern for space-, weight-, and cost-saving solutions to your hottest cooling problem. Write for New BULLETIN 360.

liquid cooling units for 50 to 50,000 watts dissipation



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Eastern AVIATION PRODUCTS

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Table I:
Micromodule Types Built to Date in Signal Corps—RCA Program

IF Amplifier: freq, 4.3 mc; power gain, 25 db; BW, 200 kc

AF Amplifier: gain, 22 db; output, 2 mw; load impedance, 5000 ohms, freq response: 100-5000 cps

RF Amplifier: freq, 49.4 mc; power gain, 6-10 db

Mixer: RF freq, 49.4 mc; osc freq, 45.1 mc; IF freq, 4.3 mc; conversion gain, 0 db

Discriminator: center freq, 4.3 mc; peak separation, 100 kc; AFC voltage, ±0.5 V across 20-K load; AF output, 0.25 V across 10-K load; input, 1.5 V at 15 kc deviation

Crystal Oscillator: freq, 45.1 mc ±0.0015%; output voltage, 0.1 V; load resistance, 200 ohms

Digital Circuits:

Binary divider—freq, 1 mc; rise time, 0.1 usec; fall time, 0.12 usec

Binary divider gate—two input "and" gate; rise time, 0.1 usec; fall time, 0.12 usec

Pulse shaper—input, 6-V square wave; output, 5-V pulse; pulse duration, 0.6 usec

Pulse generator—input, 6.5-V pulse; input pulse duration, 0.5 usec; output, 8.5-V pulse; output pulse duration, 1.5 usec max

Pulse Circuits:

Sawtooth generator—no characteristics released

Time modulator—input A, 11.5-V sawtooth with 5.2-usec duration; input B, 300-3500 cps; output, 5.2 ±0.3-usec pulse

Clipper—input, 8-V sine wave; output: 6-V square wave; rise time, 0.1 usec; fall time, 0.12 usec

Output Amplifier: input, 5-V pulse; output: 6.5-V pulse; pulse duration, 0.5 usec

Oscillator: freq, 192 kc; freq stability, 0.1%; output, 8 V min

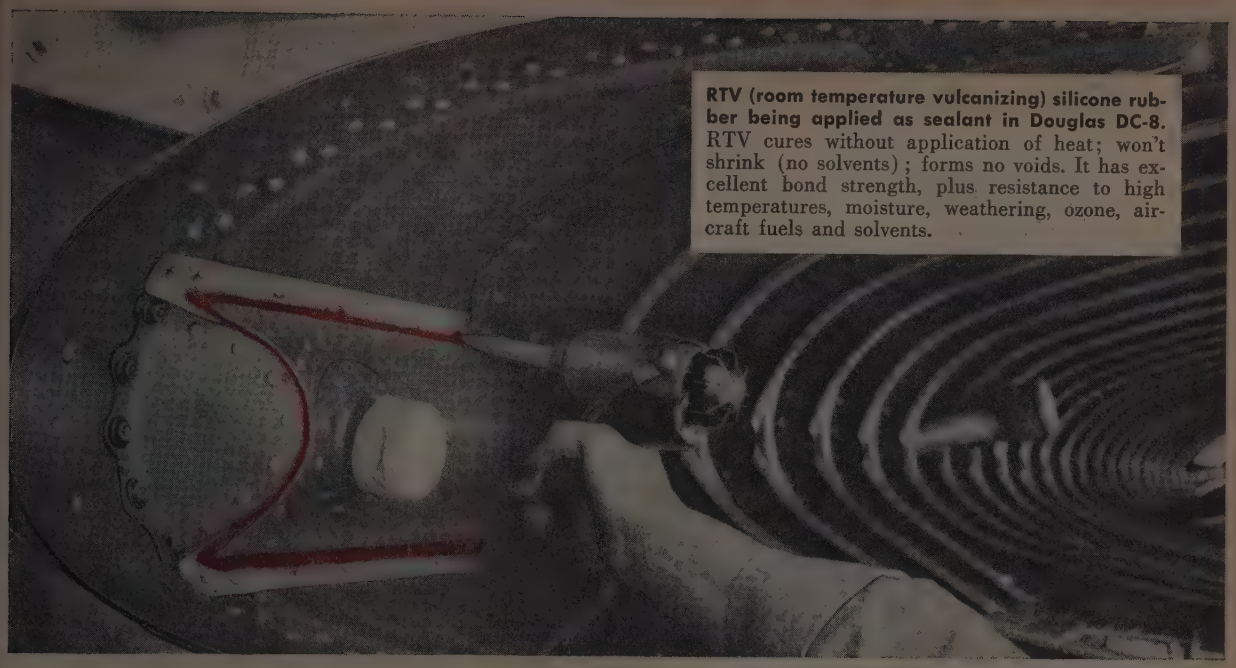
circuits program. They are 0.35 in. square and positioned on an 0.4-in. grid system. Height is flexible, with 0.4 in. the desideratum.

Made up of wire-connected components (*Table III*), each contains a functional circuit. Each component is mounted on a substrate 0.31 in. square and 0.01 in. thick. (The end substrates of a module are slightly larger—0.35 in. square and 0.02 in. thick.)

The substrates are made of alumina, glass, steatite, barium titanate, beryllia, and Fotoceram. In some cases, the substrate is the actual component.

The overall module is encapsu-

more on page 138

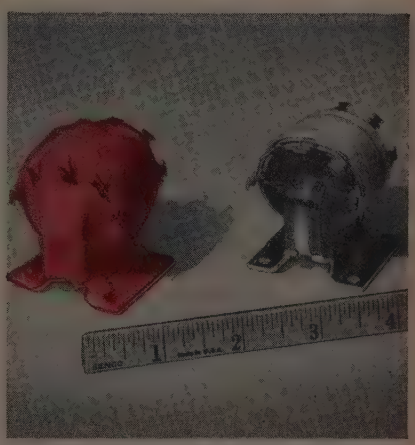


RTV (room temperature vulcanizing) silicone rubber being applied as sealant in Douglas DC-8. RTV cures without application of heat; won't shrink (no solvents); forms no voids. It has excellent bond strength, plus resistance to high temperatures, moisture, weathering, ozone, aircraft fuels and solvents.

G-E RTV silicone rubber—a superior material for tooling, encapsulating and sealing

Prototype jet engine nose cone (right) cast in RTV mold. Epoxy parts cast in flexible RTV molds have a bright, glossy surface and reproduce extremely fine detail. No parting agent is required for even the most complex parts. High tensile and tear strength is retained even after prolonged heat aging.

Close-tolerance, non-standard helix gear cast complete in low-cost, one-piece RTV mold. Previously such replacement parts had to be machined by hand. Now they can be quickly and inexpensively replaced by using the broken part as a master.



Potting and encapsulating of electrical components, such as this aircraft transformer, are easy with RTV. It can be poured, sprayed, painted or applied by dipping. Temperature resistant from −60°F to +600°F; excellent resistance to high altitude arc-over and corona. Comes in wide viscosity range.

For application data and samples of General Electric RTV silicone rubber, write to General Electric Company, Silicone Products Department, Section I-62 Waterford, N. Y.

GENERAL ELECTRIC

Silicone Products Dept., Waterford, N. Y.

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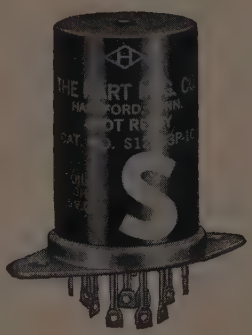
NEW . . . High Speed Polarized Relays

Fast action with freedom from bounce, plus high sensitivity and consistent operation with low distortion, are provided by small, rugged Series P Polarized Relays. SPDT, with two independent coils, they will handle over 1,000 pulses per second. Various coil resistances up to 5,000 ohms each coil. Contact ratings vary with switching speed but range from 60 MA to 2A with voltages to 120 AC or DC, dependent upon amperages employed.

Aircraft-Missile Series R & S Relays

Miniature, hermetically sealed 4PDT, Series R & S relays provide excellent reliability over their long service life. Electrically and physically interchangeable, the two series differ only in that Series S coils are separately sealed within the sealed cases, with organic matter eliminated from the switch mechanism for greatest reliability in dry circuits. Contacts MA to 10 A.



Special Mountings

Series R/S Relays are available with 10 standard mounting arrangements, plus a ceramic plug-in socket. MS-AN type connector mounting, illustrated at right, makes assembly, installation and field service extremely simple, while the connector provides a seal against moisture.

"Diamond H" engineers are prepared to work with you to develop variations on these relays to meet your specific requirements. Tell us your needs . . . by phone or letter.

THE HART MANUFACTURING COMPANY

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Phone JAckson 5-3491

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SOLID-CIRCUIT multivibrator fits on the head of a paper match. Developed by Texas Instruments, it contains the equivalent of two transistors, two capacitors, and eight resistors.

lated in Stycast 2651 epoxy resin. Transistors and semiconductor diodes are hermetically sealed on their individual substrates. (The active elements for the modules are not limited to transistors—tubes or nuvistors could also be used, according to RCA.)

Densities of 600,000 parts per cubic foot

Micromodularization appears to bridge the gap between the evolutionary component-circuit approach to microminiaturization and the revolutionary molecular circuits forecast to be available within 6-10 years. The Army's concept—presently aimed only at low power functions—cuts about nine-tenths off the size and weight of today's semi-conductor circuitry. RCA claims it has already gotten practical densities of 600,000 parts per cubic foot in experimental equipment with micromodularization.

Some 60 electronic component and materials makers (*Table II*) are under subcontract to RCA in the $13 million, four-year program, which is expected to be extended when the four years are up. If the program moves on schedule, 1962 should see the first production run of automatically made modules.

Aerospace companies that have shown interest in micromodules, according to RCA, are: Bendix, Boeing, Burroughs, Collins Radio, Control Data, Convair, Douglas, Ford Instrument, GE, Gilfillan Bros., Goodyear Aircraft, Hallicrafters, Hughes Aircraft, IBM, ITT Labs, Lear, Litton, Martin,

more on page 141

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Circuit identification now possible by printing on wire and cable insulated with TFE resins

In addition to extreme chemical resistance, TFE resins display non-wettable and anti-stick surfaces of superlative surface resistivity. However, these same properties create problems in adapting ordinary printing techniques to the identification of wire and cable insulated with TEFLON TFE-fluorocarbon resins.

The development, by wire and cable manufacturers, of techniques for pigmenting and spiral-striping this insulation has greatly simplified the design, assembly and maintenance of electronic systems. But for some applications, such as air-frame wiring, identification by printing is often preferred prior to installation of the wire into the unit or system.

Several methods based on hot-stamping techniques have recently been developed, or are under development, for printing on TFE resins. In one case, the identification is stamped on the wire and then "heat-set" to form adherent markings. By another method, the heat required to insure abrasion-resistant markings is transferred to the insulation surface during the stamping process. In both cases, the markings are legible and can be made without damage to the insulation. These hot-stamping processes are specifically designed to meet the end users' requirements in applying markings in a wire harnessing or assembly area (a typical area is illustrated above).

Thus, design engineers in the aircraft, missile and electronic industries who have taken advantage of the reliability and cost savings made possible by TFE resins are offered an added convenience. Clearly legible printing on wire and cable protected by TFE resins will satisfy an important need in production, assembly and circuit tracing.

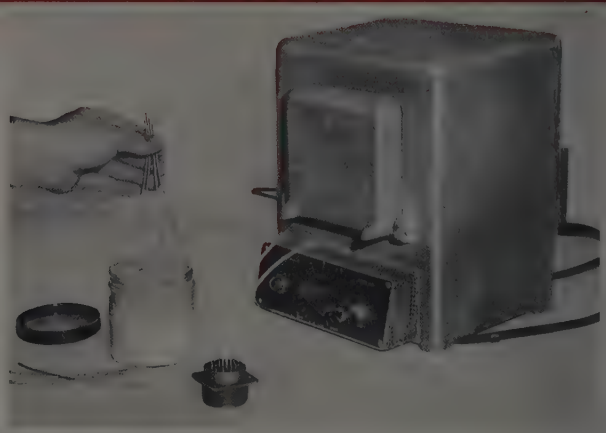
If you write to us on your company letterhead, we'll be glad to send you further information and a sample of printed wire. The address is on the next page.

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.

OVER

New techniques produce bondable surfaces on wire and cable insulated with TFE resins...improve potted and encapsulated assemblies

POTTED CONNECTIONS subjected to pressure tests clearly show the superiority of wires which have undergone bonding treatment (see results of tests in table below).



PRIMER is applied to unstripped wire ends preparatory to sintering of coating onto the surface of insulation of TEFLON TFE-fluorocarbon resins.

In many wire and cable applications, as in aircraft and guided missiles, potting of connections is often necessary to protect against moisture, corrosive chemicals and contaminants. Here the need is for a good, strong bond to the surface of the TFE resins used for insulating the conductors. But the almost universal resistance of TFE resins to chemicals and solvents, as well as their anti-stick surface, makes it very difficult to obtain a strong bond by using cements and adhesives.

Lengths of wire insulated with TFE resins and modified to provide a cementable surface have been available for several years and have been used in some cases where potting or encapsulation was desired. Recently, several manufacturers have announced the availability of wire and cable made bondable by entirely new techniques which do not discolor the surface of the insulation. Wire treated by these new techniques demonstrate improved adherence of epoxy resins, silicone rubber and other potting materials. The potted assembly is firmly sealed against moisture and contamination.

In some cases, such as where high surface resistance is required for operation at high humidity, it is often desirable to treat only the ends of the insulation to be potted. One technique for the treatment of wire ends involves the application of a "Ludox" HS colloidal primer to the insulation surface and a short heat treatment at a temperature above 330°C.

Potted connections using wire treated in this manner have excellent resistance to heat aging. In tests, potted connections using a silicone rubber resin and a standard connector were aged for 8 weeks at 175°C. The potted components showed no air leakage, and pull-out strengths were approximately the same as for the unaged control. TFE resins are rated for continuous use at 260°C., so that the maximum rated temperature of the potting compound or the electronic components is usually the limiting factor in high-temperature performance.

Wire and cable protected by TFE resins enable the design engineer to increase the reliability of equipment, conserve weight and space, and reduce costs of assembly and maintenance. A further step toward reliability and cost savings has been taken with the development of these new bonding techniques.

EVALUATION OF BONDABLE WIRE ENDS INSULATED WITH TFE-FLUOROCARBON RESINS*

Insulation treatment	Potting resin	Removal tension (average of 8 samples) (pounds)	Underwater air-pressure test (15 minutes at 20 psig)	
			No. of samples tested	No. of samples leaked
NONE (control)	Epoxy	5	4	4
NONE (control)	Silicone Rubber	2	4	4
NONE (control)	Thiokol Liquid Polymer Rubber	1.5	4	4
"LUDOX" HS (colloidal silica)**	Epoxy	14-15	8	0
"LUDOX" HS (colloidal silica)	Silicone Rubber	4-7	10	0
"LUDOX" HS (colloidal silica)	Thiokol Liquid Polymer Rubber	5-8	8	0

*AWG 22, nominal 10-mil wall, TFE resin over silverplated copper, 7/30 stranding.
**Grasselli Chemicals Dept., E. I. du Pont de Nemours & Co. (Inc.)

SEND FOR INFORMATION . . .

Consult your supplier of wire and cable insulated with TEFLON TFE-fluorocarbon resins with regard to the identification and bonding of these outstanding dielectric materials. You'll find him listed in the Yellow Pages under "Plastics—Du Pont." For any unanswered technical question about these resins, write to: **E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept., Rm. 2526, Nemours Bldg., Wilmington 98, Delaware.**

In Canada: *Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec.*

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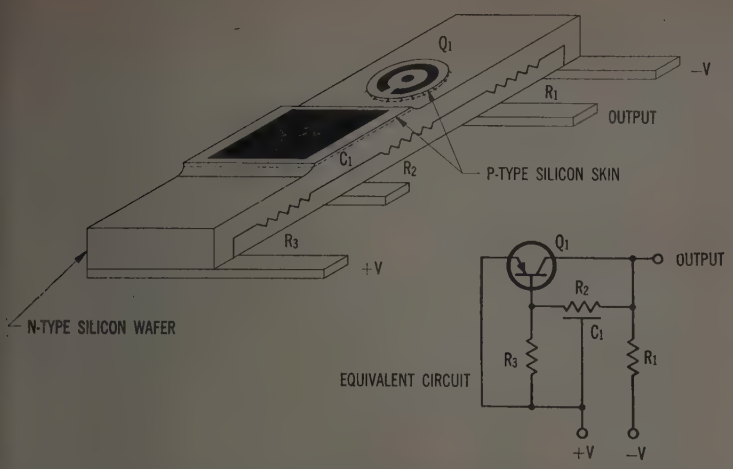


FIGURE 2: Silicon circuit of Texas Instrument phase shift oscillator and its conventional equivalent. TI uses silicon for transistor, three resistors, and capacitor. Actual size of the circuit is less than $\frac{1}{4}$x$\frac{1}{8}$x1/32 in. (240x124x25 mil).

Table II: Component Manufacturers
in Signal Corps-RCA Micromodule Program

Resistors—Allen-Bradley, Centralab, Chicago Telephone Supply, Mallory, Sprague Electric

Capacitors—Aerovox, Magnavox, Mallory, Sprague Electric

Inductors—ARF Products, RCA (Needham, Mass.)

Transistors—Philco, RCA (Sommerville, N. J.)

Diodes—General Instrument, Hoffman Semiconductor, Pacific Semiconductors

Quartz Crystals—Midland Mfg.

Materials & Processes—ACF Industries, American Lava, Ceramics for Industry, Coars Porcelain, Kawecki Chemical, National Beryllia

Flexible Printed Wiring—Sanders Assoc.

Melpar, Minneapolis-Honeywell, Motorola, North American, Raytheon, Republic, Sperry-Rand, Sperry Gyroscope, Teledynamics, United Electrodynamics, and Westinghouse Air Armament.

Two solid circuits have been displayed

Using masking, etching, and diffusion techniques, Texas Instruments has formed *solid-state semiconductor circuits* containing both active and passive elements within match-head-size blocks of silicon. Its techniques, says TI, are also applicable to germanium and other semiconductive materials. So far, diode transistor, resistor, and capacitor equivalents have been formed out of silicon (*Fig. 1*).

TI has already shown two solid circuits:

- A multivibrator using the equivalents of two diffused-base transistors, two capacitors, and eight resistors;
- An oscillator with the equivalents of a transistor, five resistors, and three capacitors (*Fig. 2*).

With its techniques, TI claims equivalent component densities of up to 34 million parts per cubic foot are possible. Representing a true molecular approach, the TI process integrates the component equivalents and their connections into the semiconductor material. It can be tightly regulated so that each component equivalent can be given the exact characteristics needed for a particular circuit.

TI estimates its integrated approach eliminates 75 percent of all conventional circuit connections. It is now working on specific com-

more on page 144

COUNTER-MEASURES ENGINEERS

Work on America's most advanced weapon systems.

At North American Aviation, such top-level projects as the B-70 and F-108 weapon systems have created unique careers with a tremendous engineering potential.

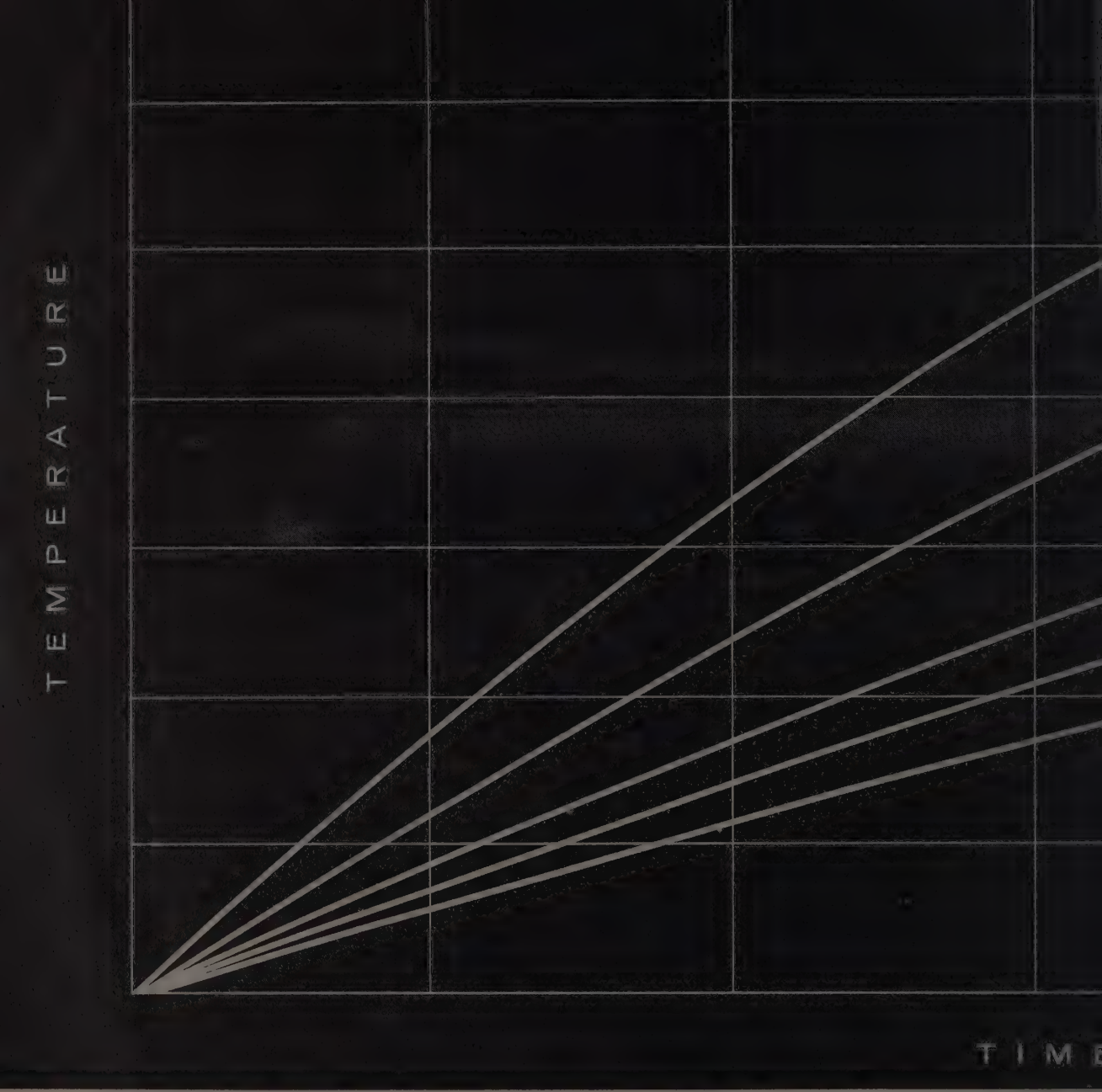
We have immediate openings for specialists and systems engineers in the field of electromagnetic and infrared countermeasures. Specialized areas include high power traveling wave tube analysis, receiver techniques, system logic, infrared systems design, and antenna and radome development. Experienced engineers are needed to establish requirements for countermeasures systems and to evaluate new components and techniques and their application to advanced systems.

Minimum requirements are actual experience in countermeasures plus B.S. degree in EE or Physics.

For more information please write to: Mr. P. F. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF
NORTH AMERICAN AVIATION, INC.

Check Employment Inquiry Form Page 153



from Westinghouse...system coordinated

Westinghouse energy storage systems are guaranteed-compatible to insure proper temperature/time conditions so essential to accurate missile evaluation.

Using typical circuits like the one shown, Westinghouse analog and digital computers make thousands of calculations to determine precisely the electrical apparatus required to provide proper air flow environments for missile testing. Capacitor energy levels, conductor spacing, collector sizing and hundreds of other factors are weighed and balanced so that over-all system impedance yields the optimum energy transfer for a given time.

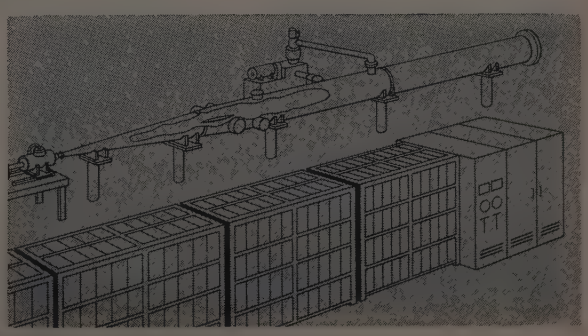
With these pre-assembly calculations, design engineers select, from the wide range of Westinghouse apparatus, components to blend properly for the most reliable and economical system. Precise repeatability of test conditions, another important factor in all missile testing, is assured by the quality and compatibility of the individual components.

Whether your program requires a capacitive or inductive system, take advantage of this Westinghouse single source guaranteed-compatibility of apparatus to be sure that your Hotshot facility will have the best energy storage system. Contact your Westinghouse sales engineer or write: Westinghouse Electric Corporation, 3 Gateway Center, P.O. Box 868, Pittsburgh 30, Pennsylvania.

J-9203

electrical equipment for Hotshot facilities

A representative Westinghouse capacitive storage system includes: fused capacitor units, packaged charger, controls and coaxial conductor system. Advantages of the capacitive system are: maximum flexibility of power level; easily expanded capacity; 30-second (or less) cycling; long life; lower initial cost; no excessive power demand for system operation.



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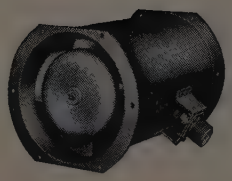

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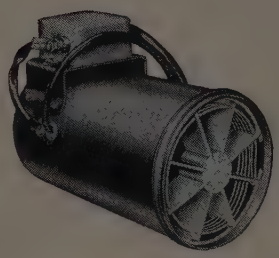
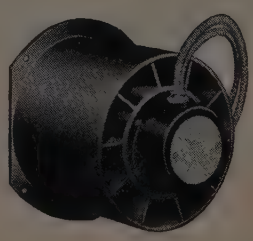


OVER 325 MODELS with 1300 designs available to meet your requirements . . . from 1/500th hp up . . . efficiency ratings up to 86% . . . pressures as high as 70" WG.

MEET MILITARY SPECS . . . accepted for airborne and ground installations by RCA, Boeing, Douglas, Motorola, Lockheed, Raytheon and many others.

VANEAXIAL DESIGN . . . motor mounted inside the fan . . . provides more air more efficiently than any other type fan.

RUGGED . . . because of simple design . . . vibration free, the outer casing, the vanes, and motor mounts are cast in one piece.



SPECIAL DESIGNS . . . We can furnish project engineers with any specially engineered fan to meet the toughest requirements and the tightest project deadlines.

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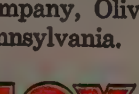
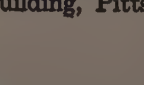
W6W I 7976-270

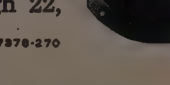
JOY AIR MOVING EQUIPMENT FOR ALL INDUSTRY



ELECTRONIC COOLING



MISSILES AND GSE



CABIN VENTILATION

DEFOGGING DE-ICING

Write in No. 102 on Reader Service Card at start of Product Preview Section

Table III: Microelements Built to Date in Signal Corps—RCA Micromodule Program

Resistors

Deposited metallic thin film: 22 100,000 ohms, 0.5 W, tempera ture coefficient less than 20 ppm/deg C

Metal oxide film: 22-180,000 ohms temperature coefficient less tha 200 ppm/deg C

Capacitors

General-purpose thin-film ceramic:

Single layer—up to 5000 uuf 100 V dc

Multiple layers—up to 0.3 uf 50 V dc

Precision thin-film ceramic:

Single layer—up to 39 uuf, 10 V dc

Multiple layers—up to 1350 uuf 50 V dc

Solid tantalum electrolytic: up to 50 uf

Inductors

Temperature - compensated ferrite core: up to 1.5 mh; Qs over 100 frequency range, 4.3-50 mc

Transistors

Equivalent to Type 2N140 (general-purpose AF amp)

Equivalent to Type 2N404 (switching)

Equivalent to Type 2N384 (VHF small signal amp, 15 db gain at 50 mc)

VHF small signal amp: 20 db gain at 70 mc

VHF power amp: 70 mc

Crystals

Quartz: 7 mc ±0.005%

Quartz: 45.1 mc ±0.005%

Quartz: 70 mc ±0.005%

Multiple Elements

Multi-resistor: deposited metallic thin film, four resistors (each 0.125 W), temperature coefficient less than 200 ppm/deg C

RC (filter) combination: ceramic capacitor with deposited metallic thin-film resistor, 40 db attenuation at 4.3 mc

LC (filter) combination: ferrite core inductor with ceramic capacitor, 4.3-50 mc

ponents for "undisclosed customers" in the aero space industry.

The *nuvistor*, a new type of electron tube for lower power applications, is smaller than other miniature tubes used for similar purposes, is much more reliable and rugged, and has superior thermal and electrical characteristics (*Fig. 3*). Nuvistors use about half as

more on page 146

There's experience behind these switches that assures the reliability you must have

MICRO SWITCH grew up with the aircraft industry. For 20 years our engineering specialists have worked in close cooperation with the aircraft and missile industry—developing precision switches of unerring reliability for applications where component failure is intolerable. It is our business to know how to best help you meet ever changing switch requirements. There are always new switches on the drawing boards and on test at MICRO SWITCH. Some may solve your switching problems immediately. Save time, save money, consult with MICRO SWITCH aviation switching specialists.

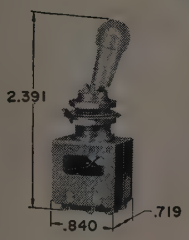
Shown here are samples of a few types—some of them with hundreds of variations—that are making history in aircraft, missile, rocket and launcher design.

For complete information on the complete line of MICRO SWITCH products for the aircraft and missile industry call the branch office near you. See the Yellow Pages.

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

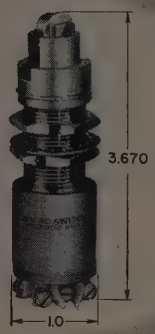
"TP" rocker actuated switch with sealed actuator and cover. Translucent or transparent keys.

(Data Sheet 141)



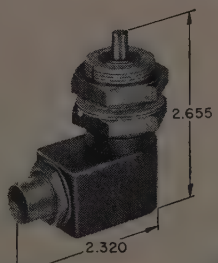
"AT" toggle switch assemblies may actuate from one to as many as a dozen basic switching units.

(Catalog 73)



"HR" Series hermetically sealed switches operate dependably up to 600°F. Switch shown has roller plunger actuator.

(Data Sheet 122)



"EN" Series hermetically sealed switches. Switch shown withstands high shock . . . meets requirements of MIL-S-901B.

(Data Sheet 152)

Honeywell
MICRO SWITCH Precision Switches

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1 Vari-Typer saves lettering time of 4 draftsmen!

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Letters tracings even 12 feet or more wide

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Why waste your high-priced draftsmen on simple lettering jobs when your office typist, using the Vari-Typer, can do these jobs 4 times faster.

Vari-Typer Model E-24 with hundreds of instantly changeable types is especially designed to give clean, sharp lettering on tracings (cloth or paper) even 12 feet or more wide!

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Table IV: Nuvistor vs Transistor

	Power Transistor		Nuvistor			
f (mc)	10	110	400	400	400	400
PO (W)	5	1.2	7	21	100	175
E (V)	62	—	62	130	500	1000
I (ma)	200	—	200	250	250	200
B-Power Efficiency (per cent)	40	17	55	65	80	87

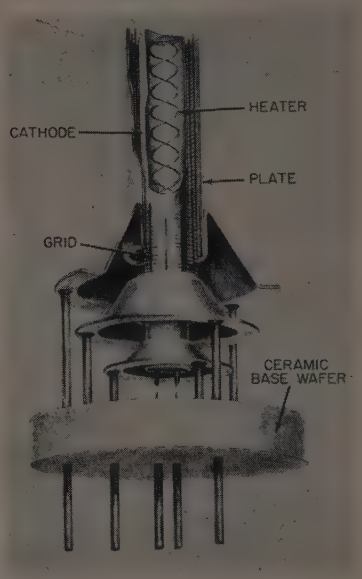


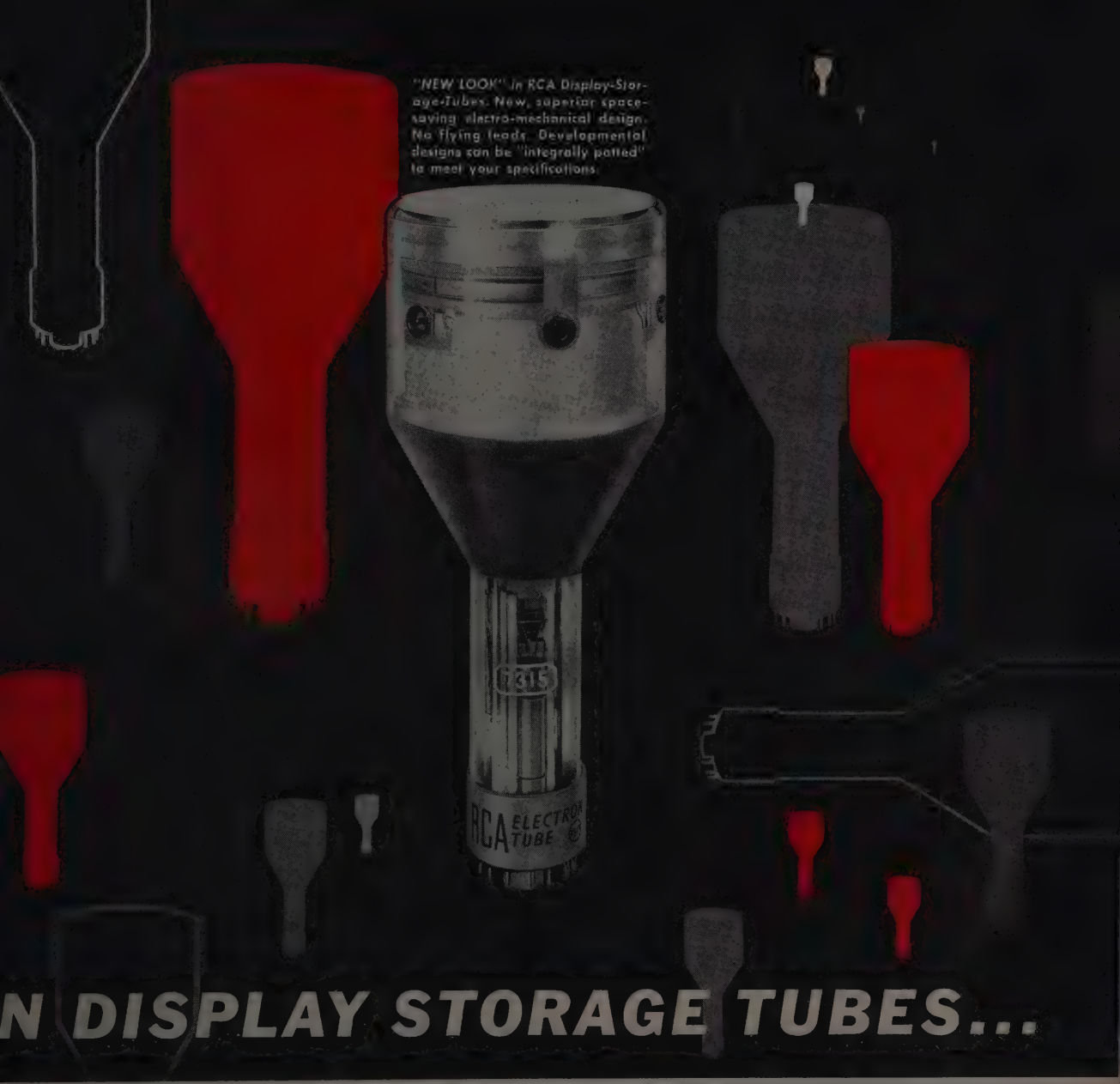
FIGURE 3: The nuvistor is an assembly of concentric, cylindrical elements spaced just a few mils apart. The flanges support the elements and are connection points for leads. The unit shown is RCA's developmental triode.

much heater power and element voltages as do their conventional tube counterparts. Lifetimes are expected to be tens to hundreds of thousands of hours. According to RCA's Electron Tube Div., the Nuvistor is in many respects superior to the transistor (*Table IV*).

New materials, design and fabrication

Key to the new design is the combination of new materials, a new type of tube construction, and new manufacturing processes. The tube uses ceramics, steel, molybdenum, and tungsten, selected be-

more on page 150


"NEW LOOK" in RCA Display-Storage-Tubes. New, superior space-saving electro-mechanical design. No flying leads. Developmental designs can be "integrally potted" to meet your specifications.
RCA ELECTRON TUBE

N DISPLAY STORAGE TUBES...

RCA provides the widest selection!

d leader in display-storage-tube development and manufacture, RCA s industry an extensive line of display-storage-tube designs.

example, RCA offers display-storage-tube types that can provide ays having high brilliance, high contrast, and very good half-tone ing. There's a choice of types with single writing or multiple writing , and with overall or selective erasure. And there's a choice of either netic or electrostatic deflection. Writing speed can be tailored to your fic application.

egardless of your display-storage-tube application, remember this t RCA Display Storage Tubes: Commercial types are readily available; ddition, a variety of developmental types can be obtained on a oling basis. If you are an equipment manufacturer, get in touch with RCA Field Representative for complete details.

PARTIAL LIST OF RCA DISPLAY-STORAGE-TUBES

RCA TYPE	BULB DIAMETER inches	DISPLAY DIAMETER inches	DEFLECTION TYPE	NUMBER OF GUNS in addition to viewing gun	TYPICAL CHARACTERISTICS	
					WRITING SPEED in./sec.	BRIGHTNESS footlamberts
7183	5■	4.0	Magnetic	1 writing	50000	1500
7315	5	3.8	Electrostatic	1 writing	3000	2750
7448	5	3.8	Electrostatic	1 writing	300000	2750
C-73788°	7	5.2	Electrostatic	1 writing	50000	750
C-73904°	5	3.8	Electrostatic	2 writing	75000	2750
C-73922°	7	5.2	Electrostatic	1 writing 1 erasing	8000 —	750
C-73931°	7	5.2	Electrostatic	2 writing	50000	750
C-73938°	5	3.8	Electrostatic	1 writing 1 erasing	12000 —	2750
C-73964°	5■■	3.8	Electrostatic	1 writing	300000	2750

°Developmental type.
■Has flying leads for screen and backplate.
■■Has integral external magnetic shield. Max. tube diameter is 5.6 inches.
Information on types similar to those listed above but with writing speed tailored to your requirements will be furnished on request. In types with 2 writing guns, the writing speed of one gun can be different from that of the other.

Your RCA Field Representatives are here to help you

GOVERNMENT SALES

- Newark 2, N. J., 415 S. Fifth St., HUmboldt 5-3900
- Dayton 2, Ohio, 224 N. Wilkinson St., BAldwin 6-2366
- Washington 6, D. C., 1625 "K" St., N.W., District 7-1260

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- Newark 2, N. J., 744 Broad St., HUmboldt 5-3900
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RADIO CORPORATION OF AMERICA

Electron Tube Division — **Harrison, N. J.**

What Lockheed is doing today to develop
Tomorrow's missiles and spacecraft

The world's first polar-orbiting satellites...the world's fastest ramjet target drone...a "fuel cell" that produces auxiliary power for spacecraft in a radically different way...a TV camera-transmitter—the world's smallest—that gives engineers and scientists on the ground a televised report of what takes place in test missiles during flight. These are just a few of the many activities and achievements of Lockheed's Missiles and Space Division.

Lockheed is System Manager and Prime Contractor of the ARPA DISCOVERER satellite series—and the U. S. Navy's POLARIS missile. Both are highest priority programs of the U. S. Government. And both are ahead of schedule.

A Lockheed MSD work-force of over 16,000—including 3,500 scientists and engineers—is engaged in all phases of missile and space technology: satellite systems development; space communications; electronics; ionic, nuclear, and solar propulsion; magnetohydrodynamics; computer research and development; flight sciences; materials and processes; human engineering; electromagnetic wave propagation and radiation—and many other advanced fields.

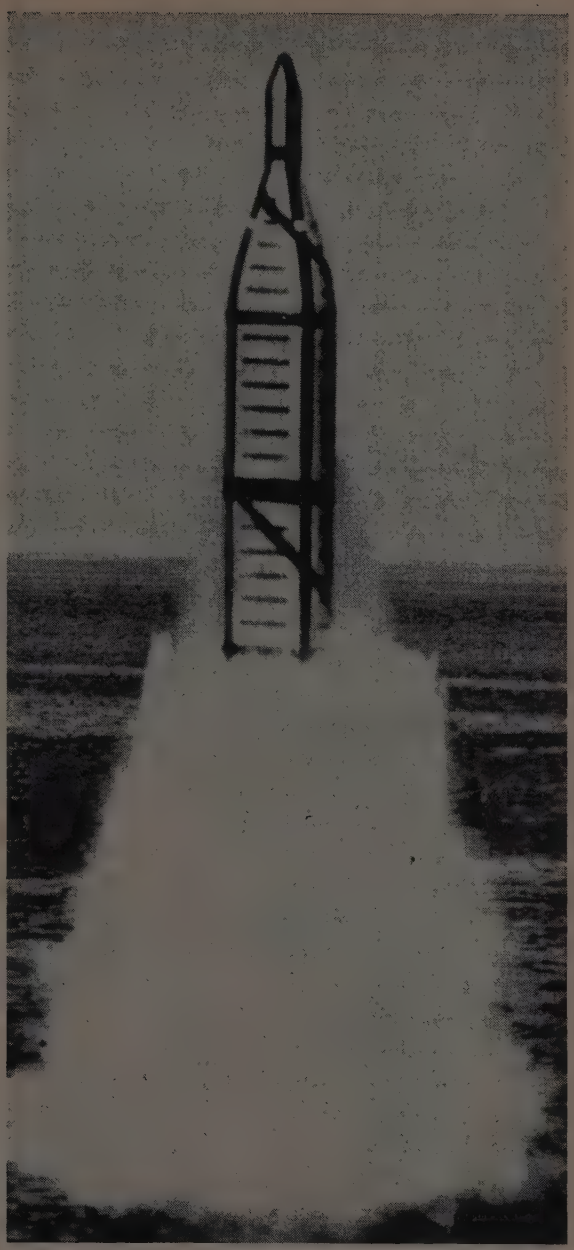
From these efforts at Lockheed will come many significant breakthroughs and scientific "firsts"—to speed the development of tomorrow's missiles and spacecraft.

Ramjet-powered supersonic target, Lockheed Q-5 KINGFISHER electronically simulates enemy attackers—is being used by U. S. Army to evaluate and sharpen our nation's missile marksmanship, increase our defense capabilities.

First polar-orbiting satellites, the Lockheed-built DISCOVERER I and II were orbited in two successive launches. Lockheed is System Manager for this ARPA advanced scientific research program.

Transmitting performance data from missiles and test vehicles, direct to ground stations, Lockheed-developed TV camera-transmitter and PAM-FM telemetry systems are acknowledged to be the world's smallest, world's best.

Revolutionary "fuel cell," under development at Lockheed, converts chemical energy directly into electrical power—for auxiliary power requirements of miniaturized spacecraft instrumentation and space communications systems.



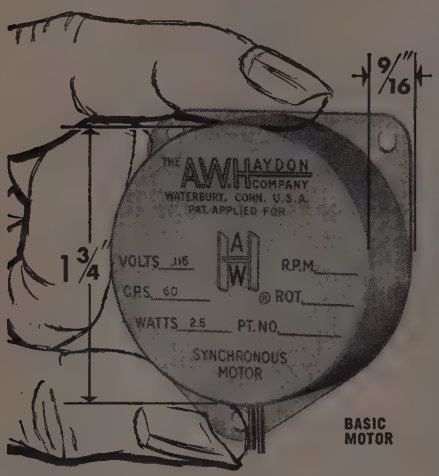
Erupting from beneath the sea, a full-scale POLARIS test vehicle demonstrates how operational missile will be launched from submerged U.S. Navy subs. Ultimate range of the POLARIS will be 1500 nautical miles.

LOCKHEED

JET TRANSPORTS • JET FIGHTERS • JET TRAINERS • COMMERCIAL & MILITARY PROP-JET TRANSPORTS • ROCKETRY
BALLISTIC MISSILE RESEARCH & DEVELOPMENT • WEAPON SYSTEM MANAGEMENT • ANTI-SUBMARINE PATROL AIRCRAFT
NUCLEAR-POWERED FLIGHT • ADVANCED ELECTRONICS • AIRBORNE EARLY-WARNING AIRCRAFT • AIRPORT MANAGEMENT
NUCLEAR REACTOR DESIGN & DEVELOPMENT • GROUND SUPPORT EQUIPMENT • WORLD-WIDE AIRCRAFT MAINTENANCE

ANOTHER FIRST...

THE ONLY *Electro-Reliable*



BASIC MOTOR

A.C. TIMING MOTOR

Thinner . . .
Quieter . . .
More Reliable . . .
More Versatile

FINGER-THIN . . .

Only 9/16 Inches Short . . . Only 1¾ Inches in Diameter . . . very compact . . . reduces the size of your equipment.

WHISPER-QUIET . . .

Strictly an electrical motor . . . practically noiseless . . . no rattling of gears or ratchets.

HIGH TORQUE . . .

¼ oz. inch at the rotor with instantaneous start and stop . . . requires only 2½ watts . . . can replace larger motors in recorders, controls and telemetering equipment.

HIGHEST RELIABILITY . . .

Longer life . . . no one-way gears or ratchets to fail . . . provides millions of operations without any trouble.

SPECIFICATIONS

Standard Voltage Ratings: 6, 12, 24, 115, 230 Volts
Frequency: 60 CPS Standard
25, 50 CPS Available
Power Input: 2.5 Watts Maximum (60 CPS)

BASIC MOTOR
Weight: 4 ounces
Speed: 300 RPM
Torque: ¼ oz-in.
Length: 9/16 inch

WITH INTEGRAL GEAR TRAIN
Weight: 5 ounces
Speed: 300 RPM to 1/6 RPH
Torque: 30 oz.-in. @ 1 RPM
Length: ⅞ inch

WITH INTEGRAL GEAR TRAIN

© 1959

Send For Special Illustrated Bulletin AWH MO-806

The A.W. HAYDON *Company*

223 NORTH ELM STREET, WATERBURY 20, CONNECTICUT

Custom Design & Manufacture Of Electronic And Electro-Mechanical Timing Devices

Table V: Nuvistor Tube Characteristics

	6DQ5	Nuvistor Beam Power Tube
Heater Power (W)	15.5	5
Min. Plate Voltage (V)	40	30
Screen Grid E_{c2} (V)	125	65
Max. Current I_p (0 bias, ma)	520	660
I_p (−10 V bias, ma)		200
Plate Dissipation Capability (W)	24	30

	6CY5 (tetrode)	Nuvistor Screen Grid Tube (tetrode)
Heater Power(W)	1.44	0.85
E_p (V)	125	60
E_{c2} (V)	80	30
E_{c1} (V)	−1	−0.5*
I_p (ma)	10	5
I_{c2} (ma)	1.5	1.7
G_m (umho)	8,000	9,000
r_p (ohm)	100,000	200,000
Max. Plate Dissipation (W)	1.7	3
Capacitances (uuf)		
Input	4.5	6.5
Output	3.0	1.4
Grid-plate	0.03	0.01

*Grid leak bias, one megohm.

cause of their electric and thermal characteristics (*Table V*). Tube elements are made in cylindrical form and assembled — with 2-3 mil spacings — concentrically on a ceramic-base wafer. All joints are brazed.

The cylindrical symmetry permits a high degree of mechanization. Prices therefore should be on a level with those of present tubes and transistors, claims RCA.

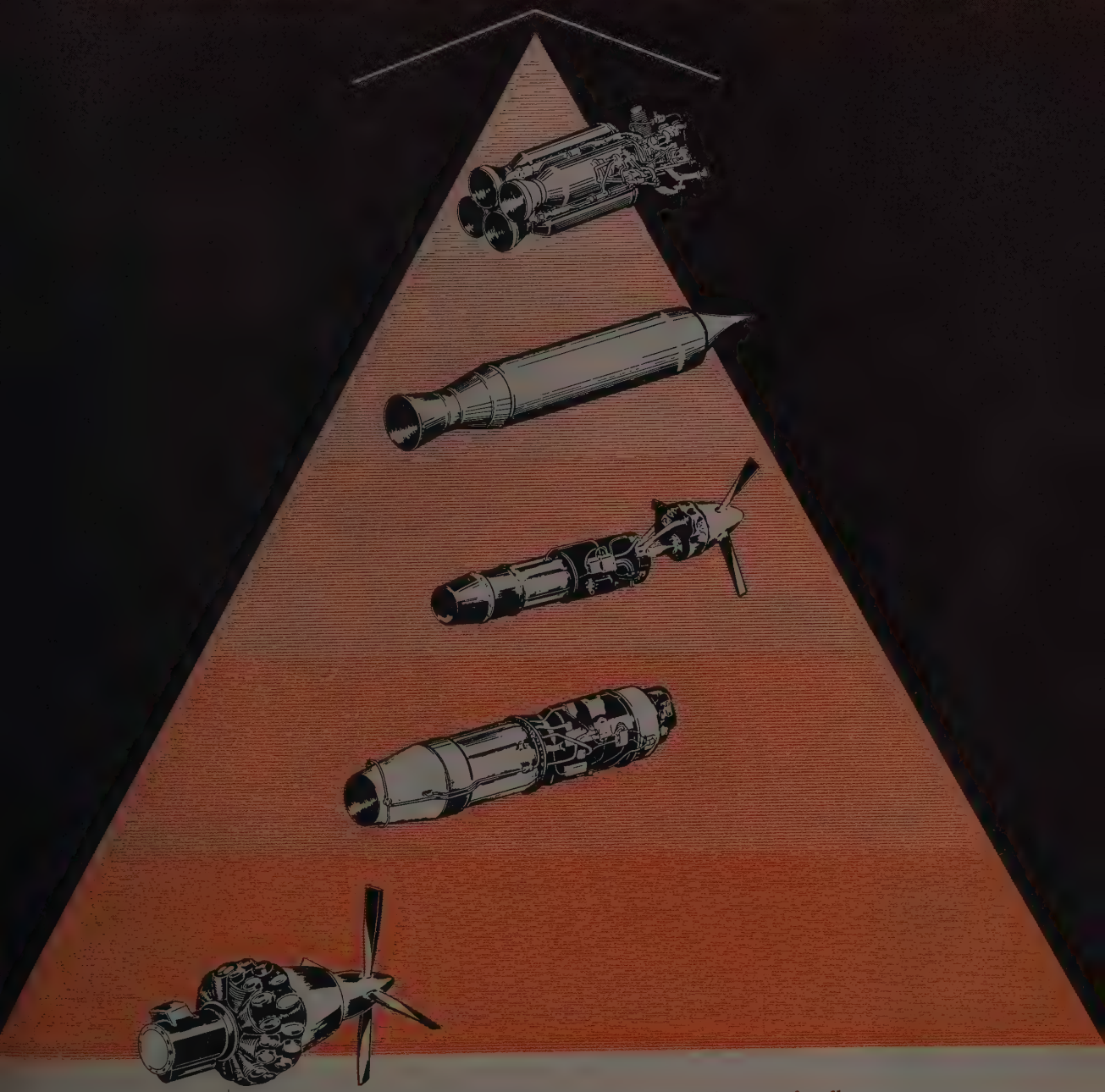
Three developmental types have been made: a small signal triode, a small signal tetrode, and a beam power amplifier. In experimental tests, the tubes have stood up under transverse shocks of 850 g, vibration over 5000 cps at two g, and repeated temperature cycling from —190 to 350 deg C.

In the future RCA expects to have nuvistors with 160 mw heater dissipation, five volts tube drop, two mils plate current, 0.001 in. electrode spacing and 0.00025 in. grid coil diameter. Limited nuvistor production is set for the latter part of next year.—JH

Write in number 150 on Reader Service Card at start of Product Preview Section
Write in No. 106 on Reader Service Card

CONTROLS

FOR THE FULL SPECTRUM OF PROPULSION SYSTEMS



Bendix* has long been a leader in supplying controls and fuel systems for all types of aircraft engines. Today, Bendix is proving to be a natural for new challenges in related missile fields—on ram jets, rockets, nuclear power, and other advanced propulsion systems. So, when it comes to controls, remember that Bendix has the background—and is anxious to share it in solving your problems. *REG. U.S. PAT. OFF.

BENDIX PRODUCTS DIVISION **SOUTH BEND, IND.**

Write in No. 106 on Reader Service Card

Bendix
AVIATION CORPORATION

ANOTHER NEW AIRCRAFT COMPONENT MADE OF BYERS AMBALLOY STEEL

AMBALLOY HIKES CAPABILITIES OF VITAL PARTS

How technically competent is your source of aircraft quality steels? Byers Amballoy steel users are served by trained metallurgists. Amballoy is uniform in workmanship, quality and cleanliness. Amballoy cuts rejections, improves product performance, meets exacting requirements.

Evaluating materials for ultra-critical aircraft and missile applications? Consider Amballoy. Byers high-quality specialty steels boost performance of gear blanks, motor hubs, upset sections, tension rods, screw shafts, steering knuckles, piston assemblies, high stressed latch and catapult hooks, flanges, and gusset plates. Versatile Amballoy is increasing payload factors in scores of longitudinally and transversally loaded parts. For details, write: A. M. Byers Company, Clark Building, Pittsburgh 22, Pennsylvania.

Mighty mite. This straight bevel gear for power unit of Hiller Helicopter has a workhorse assignment demanding plenty of strength and stamina. Made of AISI-E 9310 Byers Amballoy Steel to Specification AMS 6260E at Vard, Inc., Pasadena.

aircraft quality steels from a technically competent source

A. M. BYERS COMPANY

Write in No. 107 on Reader Service Card at start of Product Preview Section

space/aeronautics

CONFIDENTIAL

June 1959
(good until 8/17/59)

Employment Inquiry Form

(NOT an application for employment)

THIS INQUIRY FORM is a service that makes it easier for the interested reader to explore employment opportunities with organizations featuring recruitments advertising **in this issue.**

To use this Form, follow these simple steps:

(1) Tear out this page.

(2) Check off the organization(s) listed below whose employment offers are of interest to you. **Use typewriter or pencil.**

(3) Turn to the back page of this Form and answer the questions on it.

(4) Mail this form (in a stamped envelope) to:

Reader-Service Dept.
SPACE/AERONAUTICS
205 East 42nd St.
New York 17, N.Y.

We will do the rest and promptly forward a copy of your Inquiry Form to each of the organizations you have checked. Depending on their specific personnel requirements, they will get in touch with you at your home.

I am interested in the employment opportunities at:

☐ AiResearch Mfg. Co.	102	☐ Jet Propulsion Lab.; Calif. Inst. of Technology	93
☐ Autonetics, A Div. of North American Aviation	155	☐ Lockheed; California Div.	180
☐ AVCO Corp.	66, 67	☐ Los Angeles Div., North American Aviation	68, 141, 204, 218
Bendix Aviation Corp.		North American Aviation	
☐ Bendix-Pacific Div.	86	☐ Autonetics	155
☐ Research Labs. Div.	158	☐ Los Angeles Div.	68, 141, 204, 218
☐ Utica Div.	107	☐ Rocketdyne Div.	158
☐ York Div.	157	☐ RCA; Gov't. Service Personnel	184
☐ Cornell Aeronautical Lab., Inc.	36	☐ Rocketdyne Div.; North American Aviation	158
☐ Garrett Corp.	102	☐ Rohr Aircraft Corp.	160
General Electric Co.		☐ Solar Aircraft Co.	164
☐ Aircraft Nuclear Prop. Dept.	160	☐ System Development Corp.	250, 251
☐ Flight Propulsion Div.	162	☐ Texas Instruments	161
☐ Heavy Military Electronics Dept.	157		
☐ Hughes Aircraft Co.	163		

OTHER (Some organizations' recruitment advertising in this issue may have arrived too late for inclusion in the above list. If you are interested in the employment offers of any of these organizations, just note its name and the page number of its advertisement in this space. Please refer only to ads keyed to this form.): _____

_____

_____

NOTE: If you have an immediate interest in any special employment opportunity advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention SPACE/AERONAUTICS in your application.

space/aeronautics

CONFIDENTIAL

June 1959
(good until 8/17/59)

Employment Inquiry Form

Please type or print (with pencil) (NOT an application for employment)

FIELDS OF INTEREST (in order of importance, note the general fields in which you would like to work—e.g., basic research, dynamics, structures, rocket propulsion, electronic systems, pneumatics, testing, materials, production, ground support, etc.): _____

SPECIALIZED JOB EXPERIENCE (describe the specific technical areas in which you have worked —e.g., flutter, fatigue, fuel systems, circuit miniaturization, servo systems, hydraulic pumps, tool engineering, orbit mechanics, telemetry, data processing, wind tunnel testing, etc.): _____

JOBS AND EDUCATION

List your last 3 employers:

EMPLOYER	CITY & STATE	YEARS EMPLOYED	JOB TITLE OR FUNCTION

List your college and university degrees:

SCHOOL	YEARS ATTENDED	DEGREE

Special Training _____

PERSONAL DATA

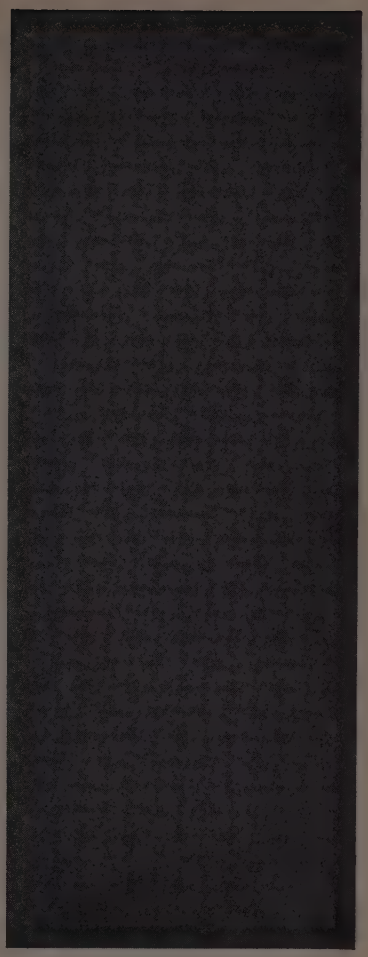
AGE ..... U. S. CITIZEN ☐ YES ☐ NO If not, when do you expect to become a citizen? .....

Name: .....

Home Address: .....

Home Telephone: .....

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to Space/Aeronautics.



It's great to be proud of the place you work

To some engineers, a job is a job is a job. But it doesn't have to be. It *can* be a career to take pride in, the way the engineers and scientists at Autonetics do.

These young men have already made Autonetics a leader in electronics and electromechanics. For example, they designed the inertial navigation systems for the USS Nautilus and Skate and the monopulse radar system for the Air Force's F-105.

These same young men now are working on new developments—an even more advanced inertial navigation system for the first nuclear-powered Polaris-carrying submarines... the guidance and control systems for the Minuteman and GAM-77 missiles... and many more.

Today at Autonetics there is room for engineers and scientists who want to have a part in these history-making activities. Please send your resume to Mr. D. F. Benning, 9150 East Imperial Highway, Downey, California.

Autonetics

A DIVISION OF NORTH AMERICAN AVIATION, INC.
Downey, California

INERTIAL NAVIGATION / ARMAMENT CONTROL / FLIGHT CONTROL / DATA PROCESSING

Among the achievements of Autonetics' young men: the first successful airborne all-inertial navigation system... first navigation system accurate enough to guide the USS Nautilus and Skate on their historic voyages beneath Arctic ice... first successful automatic star tracking by an inertial navigation system during daylight flight... first completely maneuverable, inertially stabilized gyro platform... first successful completely automatic landing system for supersonic missiles and aircraft... first transistorized portable digital computer with "big computer" capabilities.

Check Employment Inquiry Form on Page 153

NEW PROGRAM

Raytheon enters new weapons systems program and offers advancement opportunities for both Junior and Senior electronics engineers with experience in the following fields:

- Microwave engineers—component and antenna design
- Communications systems
- Guidance systems
- Computer systems
- Radar systems
- Inertial reference systems
- Feed-back control
- Auto-pilot
- Ground support
- Electronic packaging engineers
- Radar systems engineers (project management)
- Electromechanical engineer for missile control and auto-pilot design (project management)
- Mechanical engineer experienced in ground handling of large missile systems (project management)

You and your family will enjoy the many advantages of living in the metropolitan Boston area. Relocation assistance and modern benefits.

Please forward resume to:

Mr. W. F. O'Melia
Employment Manager
Raytheon Company
Bedford, Mass.

or call collect:

Crestview 4-7100
Extension 473

RAYTHEON MISSILE SYSTEMS DIVISION

Excellence in Electronics

Check Employment Inquiry Form on Page 153

ENGINEERS:

The kind of work you want in MISSILE ELECTRONICS

The kind of life you want for your family

GET *BOTH* AT

BENDIX YORK

ELECTRONIC ENGINEERS

PHYSICISTS

MECHANICAL ENGINEERS

• Challenging opportunities in CIRCUIT DESIGN, PULSE & VIDEO CIRCUITRY, MICROWAVE, DIGITAL & ANALOG COMPUTERS, SEMI-CONDUCTORS, COMPONENT AND CIRCUIT RELIABILITY.

Interesting work on FUZING TECHNIQUES, BEACONS, SIMULATORS, SPECIAL TEST EQUIPMENT.

• Bendix York offers you the opportunity for rapid professional growth and advancement. Enjoy the small-company atmosphere of an expanding division of one of America's largest engineering and manufacturing corporations . . . And the way of life in and around York, Pennsylvania is ideal for the entire family. It combines the charm and grace of rural living with the many advantages of a dynamic and progressive community.

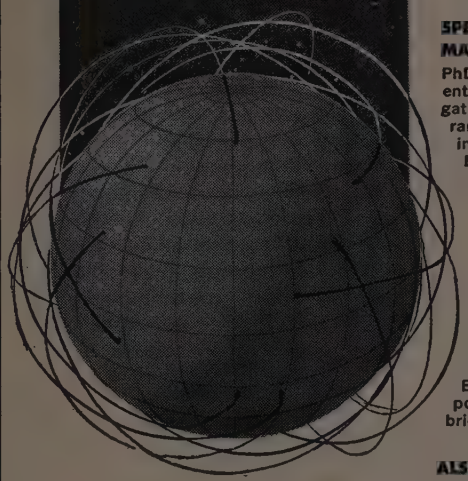
Let us hear from you!
Address replies to: Dept. S
PROFESSIONAL EMPLOYMENT

Bendix
AVIATION CORPORATION
York Division
York, Pennsylvania
"The way of work for you, the way of life for your family!"

Check Employment Inquiry Form on Page 153

SYSTEMS ENGINEERS

to work in advance areas of Systems Planning, Development and Design for Missile Detection on a Global Scale



These positions are with the Missile Detection Systems Section of General Electric and require high technical and creative capacities. All assignments offer fruitful opportunities to make state-of-the-art advances with an organization that encourages and rewards the individual contributor. The ability to function both through individual action and team leadership is highly valued. Current openings are in these areas:

ADVANCED RADAR SYSTEMS PLANNING

Work in this area calls for engineers able to visualize and define future defense and space problems and conceive advanced radar systems to solve them.

RADAR SYSTEMS ANALYSIS & DEVELOPMENT

An advanced degree and/or strong background in systems analysis and design is essential for such assignments as:

. . . analyze and define requirements for advance detection systems and determine broader parameters for such systems; establish their feasibility.

. . . analyze long range missile detection systems and specify optimum configuration on the basis of utility, performance, cost and delivery.

SPECIALISTS IN ELECTRO-MAGNETIC PROPAGATION

PhD or MS is required in this area. Scientists will carry out analysis of propagation phenomena, as related to long range missile detection. Plan detailed investigations and illustrate practicability of results. Ability to assume responsibility essential.

OPPORTUNITIES IN D & D OF RECONNAISSANCE RECEIVER DESIGN & SYSTEMS EQUIPMENT

Assignments require specialized background in one or more of these areas: VHF and UHF frequency spectra (P & L bands) • ECM • Microwave; wave guide components, Duplexers, switches, hybrids; VHF and UHF transmitters.

ALSO POSITIONS IN COMPUTER APPLICATIONS

(Knowledge of large business or special purpose computers needed) and COMPUTER PROGRAMMING (experience with IBM 704 & 709 needed.)

Write in confidence to: Mr. James P. Kinsella, Div. 60-MF.
Missile Detection Systems Section
HEAVY MILITARY ELECTRONICS DEPT.

GENERAL ELECTRIC

Court Street, Syracuse, New York

Check Employment Inquiry Form on Page 153

- INVESTIGATION OF PHYSICAL PHENOMENA
- BASIC SENSORS
- MEASURING INSTRUMENTS
- INSTRUMENTATION SYSTEMS

EXPERIENCED EXPERIMENTAL PHYSICISTS

for expansion of a group concerned with the development of basically new instruments and sensors and with the solution of advanced instrumentation and measurement problems.

The nature of the problems solved by this group varies widely, so that the principal qualifications required are an inquiring intelligence and a sound background in physics and mathematics. Present programs include work in the following areas:

- MEASUREMENT OF GEOPHYSICAL AND METEOROLOGICAL PARAMETERS IN AND ABOVE ATMOSPHERE
- VISIBLE, ULTRAVIOLET AND INFRARED RADIATION
- ELECTRON MULTIPLIERS
- MASS SPECTROMETRY
- ELECTRONICS

Final engineering and packaging are normally carried out by other groups in the organization.

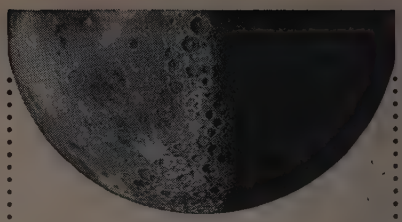
The work is stimulating and satisfying in comfortable and pleasant surroundings in suburban Detroit.

Write or wire Fred P. Barry, Research Laboratories Division, Southfield, Michigan.

Research Laboratories Division SOUTHFIELD, MICHIGAN

Bendix AVIATION CORPORATION

Check Employment Inquiry Form on Page 153



Help us solve the problems of

ION PROPULSION

Our Advanced Design Group is seeking engineers and scientists to work on low-thrust propulsion systems that will make possible the manned exploration of Outer Space. These are a few of the challenging positions:

Theoretical Physicist

Experienced in the field of particle physics, magneto-hydrodynamics and plasma physics, comparative performance of electrical propulsion systems, new methods of developing thrust from electrical propulsion systems, and direct conversion processes.

Chemical Physicists

To make studies on propellants for ion propulsion. Experienced in electronics, atomic physics, and physical chemistry.

Physicists

Primary activities will be in the field of ion sources and high vacuum techniques. Experienced in particle accelerators, ion sources, and electronics.

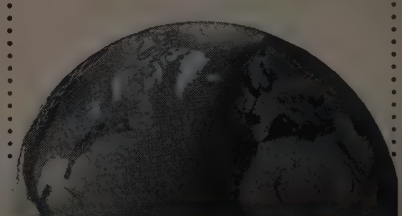
Electrical Engineer

Analysis of electrical power generators, preliminary stages designs of permanent magnet, AC induction and electrostatic generators.

Please write: Mr. F. F. Jamieson, Engineering Personnel Dept., 6633 Canoga Avenue, Canoga Park, Calif.

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.
FIRST WITH POWER FOR OUTER SPACE

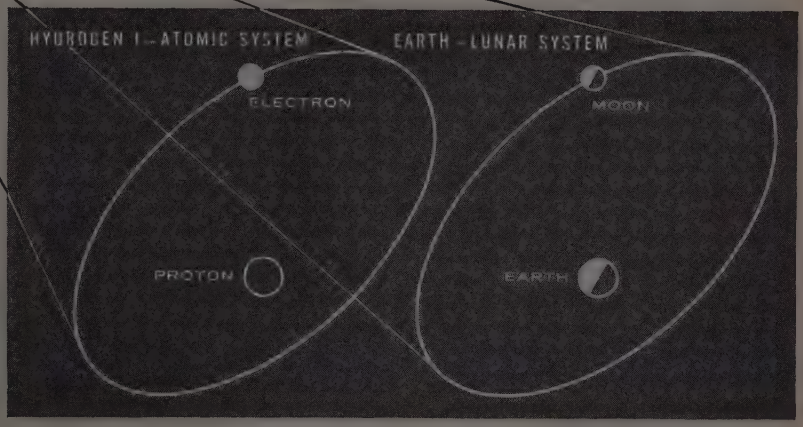


Check Employment Inquiry Form Page 153

ENGINEERS – SCIENTISTS

$$P(k_1, k_2, \ldots, k_m) = \frac{n!}{k_1! k_2! \ldots k_m!} p_1^{k_1} p_2^{k_2} \ldots p_m^{k_m}$$

Is order and organization in MACROCOSM and MICROCOSM an underlying principle of the universe... or does a fundamental state of randomness prevail in the cosmos as might be expressed by the multinomial formula at left?



BOLD MINDS

THROUGHOUT HISTORY..... **BOLD MINDS** have sought to understand the forces at work in the universe, and as they developed working hypotheses, endeavored to turn all knowledge to their own purposes, devising philosophical and mechanical systems of their own.

As old hypotheses become inadequate or untenable, thinking men devise new ones. So the concept of a "flat" world has changed to an oblate orbiting spheroid – mere speck in a vast and expanding universe; so "empty" formless space is regarded as a curved continuum occupied by random knots of turbulence (creating the new branch of mechanics – hydromagnetics).

Today new horizons of discovery and surmise arise before the speculative mind.

ENGINEERS AND SCIENTISTS AT REPUBLIC FEEL KINSHIP WITH ALL BOLD MINDS OF PAST AND PRESENT, AS THEY FACE THE EXHILARATING CHALLENGES OF CREATING VEHICLES TO FLY IN ENVIRONMENTS WHERE NEW APPROACHES IN THERMO/AERODYNAMICS MUST BE MADE...AS WELL AS APPROPRIATE PROPULSION AND ELECTRONIC SYSTEMS TO POWER AND GUIDE TRANSIT IN SPACE

Groups of Research, Development and Experimental Engineers and Scientists at Republic Aviation are now working on projects over the whole range of aeronautics and astronautics – from supersonic and hypersonic weapons systems, both manned and unmanned, to plasma propulsion and space electronics.

Imaginative professional men at many levels of experience are invited to inquire about opportunities indicated below:

ELECTRONICS
Inertial Guidance & Navigation
Digital Computer Development
Systems Engineering
Information Theory
Telemetry-SSB Technique
Doppler Radar
Countermeasures
Radome & Antenna Design
Microwave Circuitry & Components
Receiver & Transmitter Design
Airborne Navigational Systems
Jamming & Anti-Jamming
Miniaturization-Transistorization
Ranging Systems
Propagation Studies
Ground Support Equipment

THERMO, AERODYNAMICS
Theoretical Gasdynamics
Hyper-Velocity Studies
Astronautics Precision Trajectories
Airplane/Missile Performance
Air Load and Aeroelasticity
Stability and Controls
Flutter & Vibration
Vehicle Dynamics & System Designs
High Altitude Atmosphere Physics
Re-entry Heat Transfer
Hydromagnetics
Ground Support Equipment

PLASMA PROPULSION
Plasma Physics
Gaseous Electronics
Hypersonics and Shock Phenomena
Hydromagnetics
Physical Chemistry
Combustion and Detonation
Instrumentation
High Power Pulse Electronics

NUCLEAR PROPULSION & RADIATION PHENOMENA
Nuclear Weapons Effects
Radiation Environment in Space
Nuclear Power & Propulsion Applications
Nuclear Radiation Laboratories

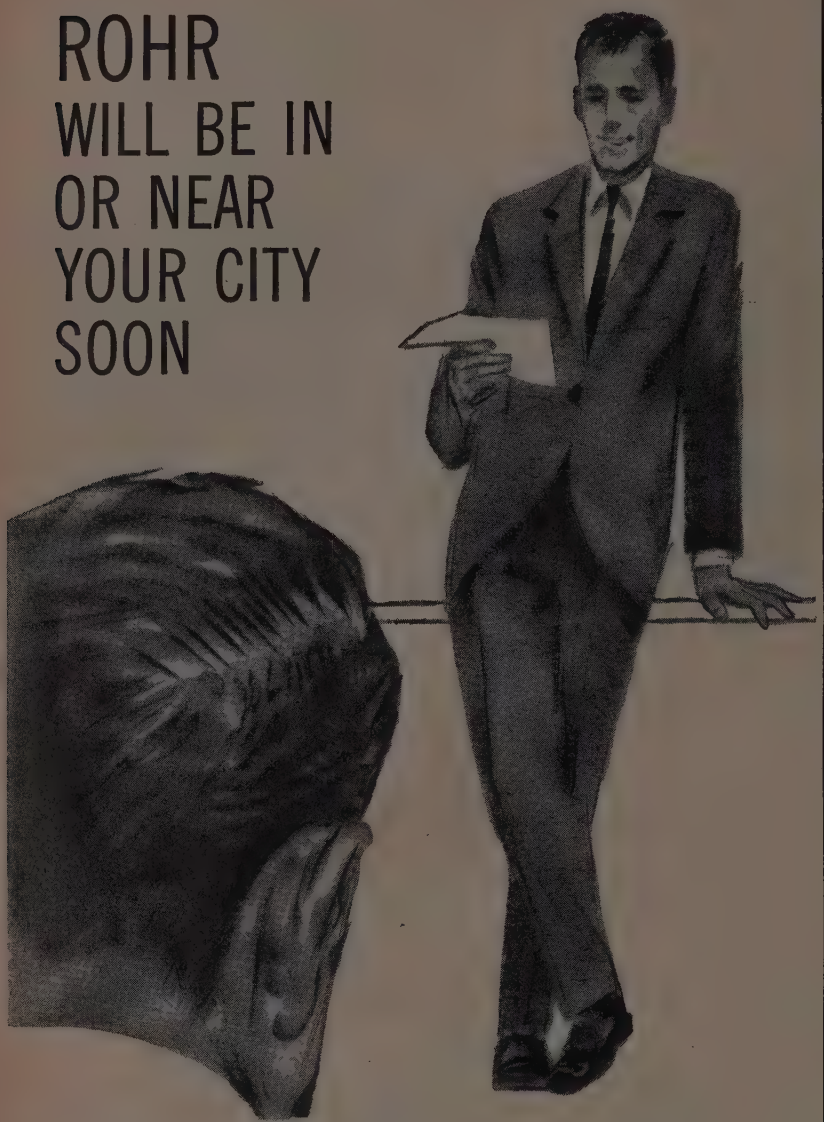
A new $14,000,000 Research Center – to be completed this year – is part of Republic's far-ranging R&D programs aimed at major state-of-the-art breakthroughs in every flight regime & environment.

Send resume in complete confidence to:
Mr. George R. Hickman, ENGINEERING EMPLOYMENT MANAGER – DEPT. 6F

REPUBLIC AVIATION
FARMINGDALE, LONG ISLAND, NEW YORK

Engineers . . . make your move to a climate of opportunity.

ROHR WILL BE IN OR NEAR YOUR CITY SOON



Professional opportunities in Southern California for engineers in these fields: Structures, Design, Welding, Bonded Structures, Liaison, Industrial. Men from Rohr will soon be conducting personal interviews in the following cities:

Akron	Chicago	New York
Baltimore	Cincinnati	Philadelphia
Buffalo	Dallas	St. Louis

Detailed resumes from qualified applicants will be held in confidence and given prompt attention in the arrangement of local interviews. Address J. L. Hobel, Industrial Relations Manager, Rohr Aircraft Corporation, Chula Vista, California.

SA-1

ROHR AIRCRAFT CORPORATION
CHULA VISTA AND RIVERSIDE, CALIFORNIA

Check Employment Inquiry Form on Page 153

APPLICATIONS ENGINEER

Only 3-5 years' airframe experience—yet high salary to man with proper capabilities

Opening for an engineer with a background in aircraft applications. Must be capable of estimating and predicting the performance of aircraft and missiles utilizing nuclear power plants. Working know-how of effects of power plant installation and airframe configuration on performance is expected.

REQUIREMENTS: MS in Aeronautical Engineering with 3 to 5 years' experience with an aircraft manufacturing firm in applications activities.

► PUBLICATION OF TECHNICAL PAPERS IS ENCOURAGED

► TUITION REFUND IS PROVIDED FOR GRADUATE WORK

Write in confidence including salary requirements to:

Mr. P. W. Christos Div. 60-MF
AIRCRAFT NUCLEAR PROPULSION DEPARTMENT

GENERAL ELECTRIC

P.O. Box 132 Cincinnati 15, Ohio

Check Employment Form on Page 153

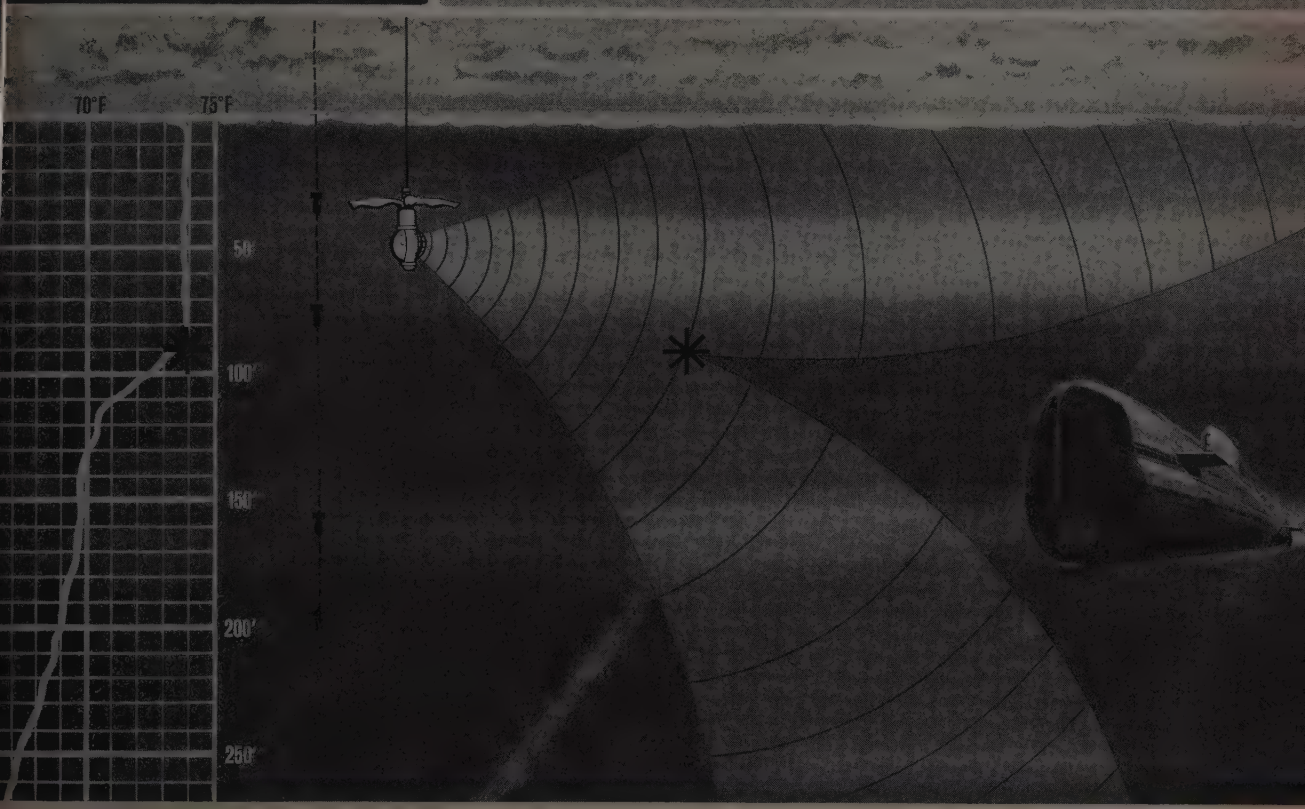
IMPORTANT

In filling out "Employment Inquiry Form" be sure to print clearly. When you check more than one company, the form must be photostated so that each company receives a copy.

idea:

Submarines can hide within range of helicopter-borne sonar by "riding the thermocline" water temperature change that casts shadows in sonar search patterns. Precise temperatu vs.-depth records allow the operator to spot thermoclines and change his search pattern to l into the shadows. Existing gear "worked", but it took too long and could not define the shad zones very accurately. TI engineers created an automatic recorder, the **bathythermograph,** m accurate than a laboratory thermometer, that gives results instantly where they were needed – the helicopter. Small as a portable typewriter, it easily fits with the sonar into the space availab

RESULT: Same sonar—fewer missed submarines.



design, manufacturing and quality engineers—3-10 years experience

high-gain careers for problem-solvers

YOUR SPECIAL TOUCH with unsolved problems buys you a solid future in any of Texas Instruments major military programs — Antisubmarine Warfare, Heavy Surface Radar, Missile Systems, or Electronic Surveillance. For example, you can try your hand at solving the Navy's clearly stated ASW requirement: Build *something* that will detect and classify a fast-moving submerged submarine at depths of 1500 feet, more than 50 miles from your aircraft.

Your experience in one of the following technologies may find immediate application in one of our four major programs:

radar • sonar • infrared • magnetic anomaly detection • passive detectors • servos • navigational systems • special-purpose computers • timers • programmers • microwave • telemetering • data link • optics • video mappers • visual displays • intercom

We require a steady influx of exceptionally-qualified men in these technologies. To learn more about us and how we can fit into your career plan, write for a copy of "We can tell you this much about Apparatus division" to:

J. R. Pinkston *Professional Placement*

APPARATUS DIVISION

TEXAS INSTRUMENTS INCORPORATED

6000 LEMMON AVENUE • DALLAS 9, TEXAS

Check Employment Inquiry Form on Page 153

current career openings

EE's & PHYSICISTS:

radar (ground and airborne), antenna & microwa components, missile guidance, servo-mechanis telemetry, digital circuits, infrared design, syste studies, & flight test.

ME's:

antenna, mechanisms, miniaturization, thermodyna ics, refrigeration, insulation, packaging, & structu design.

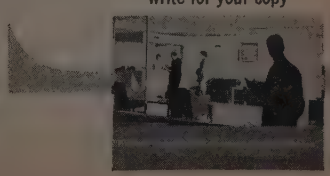
INDUSTRIAL ENGINEERS:

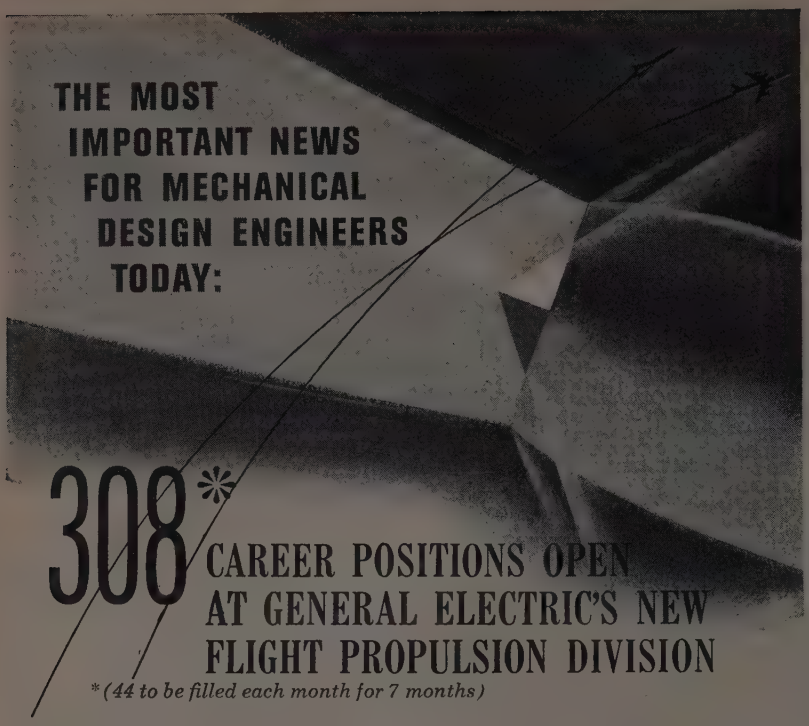
cost estimating, quality control, & quality assura studies.

MANUFACTURING ENGINEERS:

tooling design & manufacturing planning & supervis (Degrees in EE or ME.)

write for your copy





THE MOST IMPORTANT NEWS FOR MECHANICAL DESIGN ENGINEERS TODAY:

308* CAREER POSITIONS OPEN AT GENERAL ELECTRIC'S NEW FLIGHT PROPULSION DIVISION

**(44 to be filled each month for 7 months)*

It's not just the high number of new jobs open at FPD—but the diversity of the opportunities *within one organization* that's important to your future.

You'll find assignments here in Research, Development, Final Design, Production and Test of almost any type of advanced flight propulsion system.

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Most current positions require background in turbomachinery D&D; some do not. Experience from 3 to 10 years.

(There are also opportunities at Managerial and Specialist levels for Aerodynamicists, EEs, ChEs, Metallurgists, Physicists and Mathematicians.)

For more information about Flight Propulsion Division—and the professional and living advantages of the new Cincinnati, with its fine, uncrowded schools, some 30 active engineering societies, famous symphony orchestra...write for illustrated brochures #50 and #51. *For immediate placement consideration enclose your resume.*

A Partial List of

DIVISION-WIDE PROJECTS AT FPD

...CJ 805 aft fan engine to power Convair 600—Commercial Engine Dept.

...J79, famous powerplant of many applications, including F-104A—Production Engine Dept.

...J93 development engine with Mach 3 capability, will power B-70 & F-108—Jet Engine Dept.

...High Mach, high energy powerplant in early development...exotic propulsion systems using plasma and ion power sources—Flight Propulsion Laboratory Dept.

ALSO: A turboshaft project...and a well-advanced VTOL project for vertical and horizontal flight of a fixed wing aircraft... and other classified projects of unusual interest, with both commercial and military applications.

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Basic Powerplant Design—Turbomachinery aero • nozzle design • reliability • performance & cycle analysis • installations/applications • component design.

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Address Mr. Mark Peters, Bldg. 100, Dept. 60-MF

FLIGHT PROPULSION DIVISION

GENERAL ELECTRIC

Cincinnati 15, Ohio

Check Employment Inquiry Form on Page 153

Career Openings For ENGINEERS

Expanding R&D programs have created urgent needs for qualified engineers with 3 to 5 years experience as:

STRESS ENGINEERS
DYNAMICS ENGINEERS
WEIGHT CONTROL ENGINEERS
ANALOG COMPUTER ENGINEERS

ELECTRONIC ENGINEERS

B.S. or M.S. in E.E., Physics or Math with experience in one or more of the following fields:

GUIDANCE
INSTRUMENTATION
TELEMETRY
TRANSISTORIZATION
PROGRAMS
ANTENNA DESIGN
ECHO ENHANCEMENTS
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RELIABILITY ENGINEERS-SPECIALIST

B.S. in A.E., M.E. or E.E. with expr. in state-of-the-arts aircraft reliability techniques. For technical surveillance of overall projects in this field.

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B.S. or M.S. in A.E., M.E. or E.E. with 3 to 5 years aircraft experience. Must be capable of designing complete, hydraulic or pneumatic systems, evaluate power requirements, pump capacities, fluids, and temperature ranges.

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Requires advanced degree in Engr., Psychology or allied fields with expr. in defining activities to be performed by military weapons systems personnel. To provide human factors criteria for design engineers—work with project personnel for optimum utilization of men and systems during design and development.

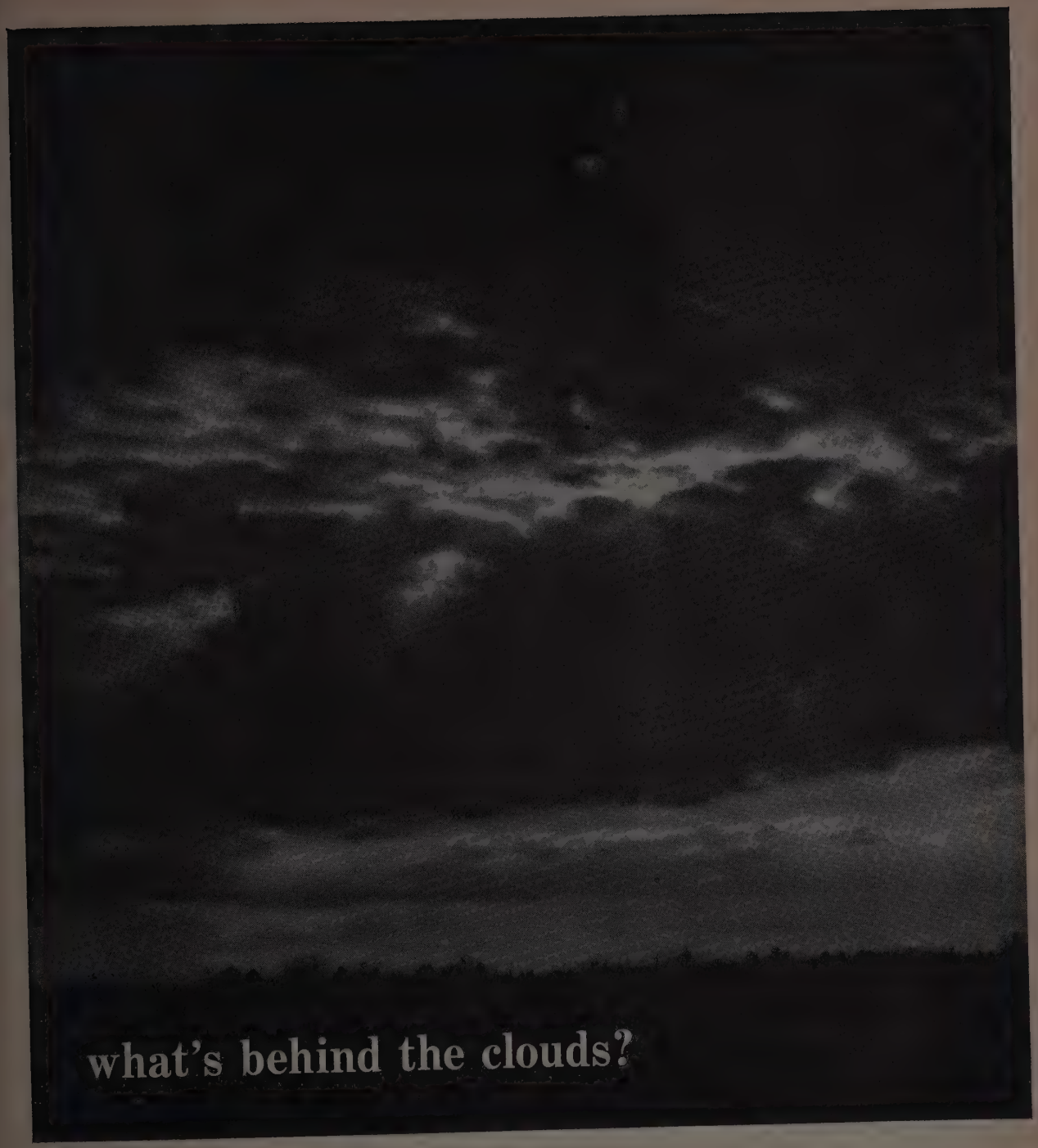
THERMO-DYNAMICISTS

B.S. or M.S. in A.E. or M.E. with 3 to 5 years experience in theoretical process and research. To design and construct apparatus, perform tests, reduce data and write-up experiments in thermodynamics, heat transfer and fluid flow.

Please mail brief resume to C.M. Jones, Employment Mgr. or Telephone Gene Gregg, MU 34681 (Wichita). Proof of citizenship will be required.

BEECH AIRCRAFT CORPORATION

Wichita 1, Kansas



BEHIND THE CLOUDS hides a cunning enemy with ever-improving weapons to threaten our security. To deter these airborne aggressors is the job of the all-weather interceptor, our first line of defense.

Partaking in a giant chess game, a Hughes Airborne Systems Engineer is constantly fed intelligence information regarding the most recent enemy advances. He asks the question, "How effective are present interceptors against the new enemy capabilities, and how can we counter this challenge?"

The Hughes Airborne Systems Engineer is concerned with the design of hardware, but he does not design hardware. He is more interested in the broader systems aspects. Taking an analytical approach, he must solve the interacting problems of performance, reliability, maintainability, and operability.

If this type of systems engineering interests you, investigate the assignments now open in:

SYSTEMS ANALYSIS • SYSTEMS EVALUATION
SYSTEMS DESIGN • SYSTEMS FLIGHT TEST
SYSTEMS DESIGN CO-ORDINATION

The salary structure for these positions reflects the advanced nature of the assignments. Please inquire by writing directly to Dr. Allen Puckett, Director, Hughes Systems Development Laboratories.

HUGHES AIRCRAFT COMPANY
CULVER CITY 40, CALIF.

HUGHES

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Check Employment Inquiry Form on Page 153

ENGINEERS

experienced in missile and gas turbine fields

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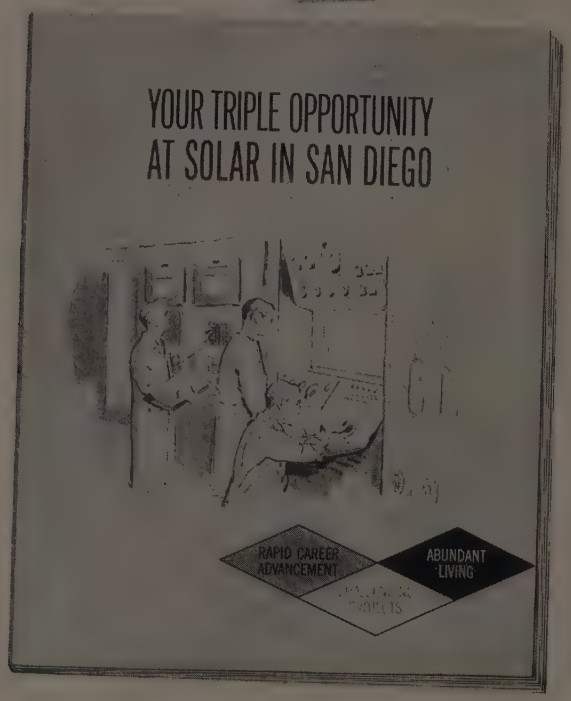

GET THE FACTS about Solar and your *triple opportunity* — and do it without delay.

Opportunity #1: The chance to get in on the ground floor and gain a key creative position with tremendous potential. Solar is humming with exciting and challenging programs. Solar's Missile and Space Group has several highly advanced projects under way, including a new ARPA Project involving a completely new anti-missile defense system. Many openings also exist in Solar's fast-moving gas turbine programs.

Opportunity #2: You don't get lost in the crowd! Solar is a medium-sized company (2500 people in San Diego) with a successful history since 1927. Personnel policies are advanced. Salary and performance reviewed semi-annually. Liberal relocation allowances. Professional status of engineers is fully appreciated and recognized. A new 60,000 sq. ft. engineering building, necessitated by expanding research and development, will be completed in 1959 on the edge of San Diego Bay.

Opportunity #3: The chance to live better in sunny San Diego. This famous resort area has the finest year-around climate in the U.S. Recreational, cultural and educational facilities are excellent. You and your family will enjoy life more at Solar in San Diego.

Send for brochure giving complete details. Write to Louis Klein, Dept. E-603, Solar Aircraft Company, 2200 Pacific Highway, San Diego 12, Calif. Why not send along your resume of qualifications to save time?

SOLAR
AIRCRAFT COMPANY
SAN DIEGO
DES MOINES

IMPORTANT

In filling out "Employment Inquiry Form" be sure to print clearly. When you check more than one company, the form must be photostated so that each company receives a copy.

Check Employment Inquiry Form on Page 153

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New York, N. Y.

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product index to advertising

THIS IS A SPECIAL REFERENCE to the product information given in the advertisements in this issue. It is intended solely to help the reader make the best use of these ads. Therefore the index does not necessarily cover all the products made by each advertiser. Also, cross-listings are not intended to exhaustively describe each product but merely to make sure that each product can be found with reasonable ease by the reader looking for it.

Similar indexes to services and employment opportunities featured in ads follow this index.

Advertisements for which complete proofs were not available to the Editorial Department by the closing date are not necessarily covered by these indexes. (Proofs can be forwarded internally by the Production Department only for advertisements meeting the closing dates.)

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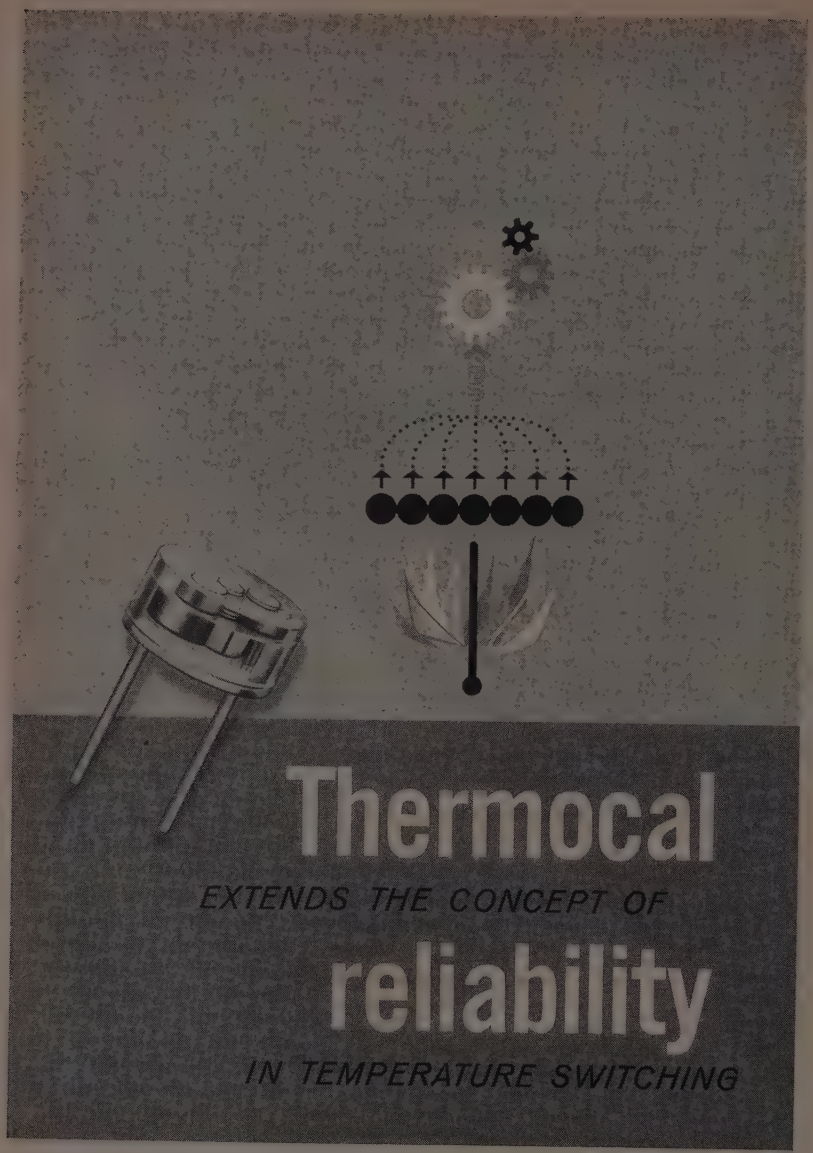

THYRASTAT®

...fail-safe overheat protection

NEW miniature, hermetically sealed, single-shot, temperature-sensitive switch provides FUNCTIONAL RELIABILITY for positive over-temperature protection. Factory preset within 1% of specified temperature.

TEMPERATURE RANGE: +113° F. to +1500° F.
CURRENT RANGE: 10 to 500 Amperes
SPST Normally open or closed types.

Patents Pending

Write for new Brochure containing complete specifications:
advanced concepts of precision specialty switches for maximum protection

thermocal

1631 COLORADO AVENUE
SANTA MONICA, CALIFORNIA

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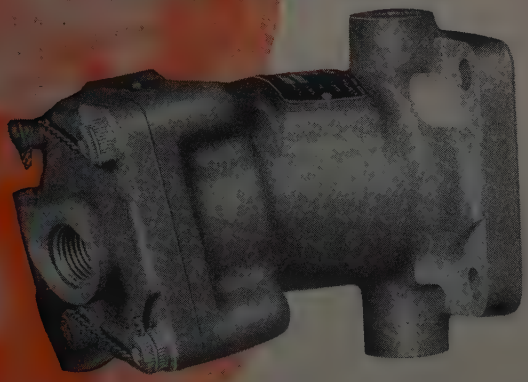
engineering Pesco production

Creative engineering
...for the space age

PESCO B-W BORG-WARNER

"Hummingbird" Pump-Motor, Model 013685



Miniature Pump-Motor, a remarkable Pesco development in hydraulics, saves critical space and weight on jets and missiles. Piston-type hydraulic unit can be used as either pump or motor without modification for rotation in either direction. Model shown here delivers 2.5 gpm at 3000 psi, operates at 24,000 rpm from direct drive, weighs 2.1 lbs., handles fluids from —65° to 550° F. All-steel unit features spherical piston ring, all-metal O-rings, constant-velocity universal joint. Basic design can be varied to meet your specifications.

This is but one of many exciting Pesco developments in hydraulic pumps, motors, power packages, servo valves.

HYDRAULICS

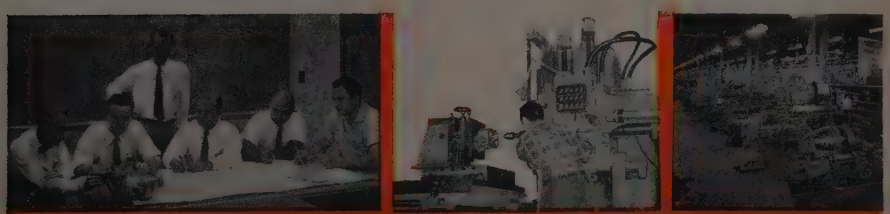
The miniaturized pump-motor shown here demonstrates Pesco capabilities for engineering high-performance hydraulic components. These can be applied to your space age program wherever pressurized flow and precise control of fluids are vital.

Creative Pesco engineers are making outstanding contributions to many of the most advanced projects. Working closely with customer engineers, they are meeting the most sophisticated requirements for space and weight savings, environmental resistance and performance of hydraulic accessories and systems.

If you want fast action — from initial studies through prototypes to quantity production — utilize the creative engineering available at Pesco.

PESCO PRODUCTS DIVISION
BORG-WARNER CORPORATION
24700 North Miles Road • Bedford, Ohio

Export sales: Borg-Warner International Corporation • 36 South Wabash Ave. • Chicago 3, Ill.



Pesco creative engineering is strongly supported by modern facilities, fully equipped for research, development, design, prototype production, qualification testing and quantity manufacture.

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Gevaert X-ray films are used to inspect wing structure of Convair B-58 "Hustler."

GEVAERT STRUCTURIX X-RAY FILMS

.....for proof of the product

Quality-conscious industries rely on Gevaert X-ray films to assure product perfection. These films probe deep to search out flaws, and emulsion and base characteristics combine to define and separate the most delicate tones.

Gevaert Structurix X-Ray Film Types—

D-2: A unique slow-speed film of incomparable quality. Gives highest detail and finest grain available in any film. Designed especially for rechecks and production inspection of thin or medium sections, and light metals.

D-4: A medium-speed fine grain film for inspecting medium thick or thick sections of light metals, and thin sections of heavy metals.

D-7: A high-speed film for medium to fairly thick light metals, thin and medium sections of heavy metals. Also for gamma radiography.

If you would like the details on all five Structurix Films, send for the free new booklet "Gevaert Industrial X-Ray Films."

GEVAERT **THE GEVAERT COMPANY OF AMERICA, INC.**
321 West 54th Street, New York 19, N. Y.
District Offices: Lincolnwood, Ill. (Chicago) • Los Angeles Dallas • Denver • San Francisco

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CLASSIFIED

Miniature, All-Purpose CALCULATOR

A precision instrument that will do *all* the calculations of larger expensive desk models. Weighs only 8 oz. Fits Hand. Fast, accurate, sturdy . . . completely portable. Ideal for all on-the-spot calculating. Fully guaranteed. Write for *Free* literature, prices, name of nearest dealer.
THE CURTA COMPANY Dept. 15
2735 W. North Shore, Chicago 45, Ill.

TECHNICAL MANUALS COMPANY
1214 Erie Street **Utica 4, N. Y.**
REdwood 2-2313

AAF—Stock—Lists—Federal Stock Numbers on Parts—Engines—Late Planes—Radio—Radar—Signal Corps TM—Manuals on Test—Radio—Radar & Automotive Equipment. Send us your requirements.

RHEEM SOLVES TOUGH MACHINING PROBLEM

The compressor case for General Electric's small turbo-jet engine must be fabricated from a high nickel-steel chrome alloy. So complex are the machining operations, most metalworkers are not equipped to tackle the job. Machining a welded assembly already processed and hardened is a job for experts only. That is why General Electric brought the problem to Rheem, who, for more than two decades, has been a leader in precision metalworking of difficult materials and complex components for the defense and aircraft industries.

Result: Some difficult days for Rheem men and their machines but a final product that meets the specs to perfection.

Moral: Bring your metalworking problems to Rheem. You'll find a happy solution. For more information, write Dept. SA-714-1.

RHEEM MANUFACTURING COMPANY
Defense and Technical Products Division
11711 woodruff avenue, downey, california

Rheem

PROPULSION and MISSILE SYSTEMS • PRESSURE VESSELS • ORDNANCE • DRONES • ELECTRONICS • RESEARCH

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More than 450 different parts are now available from stock in the new Marman warehouse.

With the completion of a new warehouse, Marman has initiated a unique inventory program for off-the-shelf delivery of many types of Marman Products.

Now, aircraft/missile engineers and buyers can select high quality Marman Clamps, Couplings and Joints from standardized styles . . . for immediate delivery!

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This new inventory program is designed to provide better service to all of our customers. By ordering standardized products for fastening and joining, wherever possible, manufacturers can eliminate the extensive lead time normally needed for tooling and production.

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At present, 10 basic Marman Products (shown above) fit into this inventory program. These clamps, couplings and joints are now available in a wide range of stock sizes, styles and materials that include 458 separate part numbers. As other products adapt to standardization, they will be added to this list.

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now safeguards passenger jets

assures... maximum range
lower operating costs
increased safety
peace of mind... for crew and passengers!

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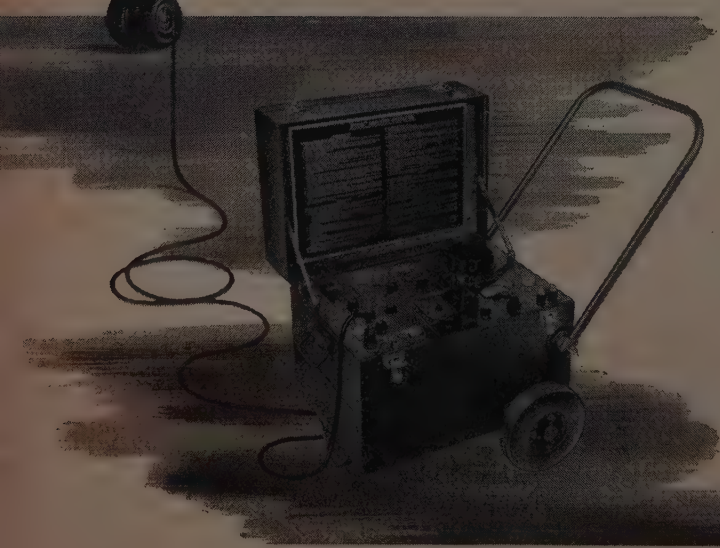

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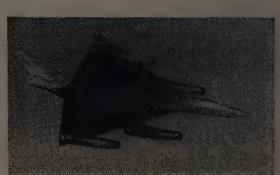

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DAYTON, OHIO: 5606 Rice Place • BE 3-4411
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ENGLAND: BRYANS AEROQUIPMENT LIMITED, 15, Willow Lane, Mitcham Surrey

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EJECTION BOLT

AN EJECTION bolt that combines shackle and gun in one unit—and so can be used for suspension as well—has been designed by Ted Geffner, 3825 Hampton Rd., Pasadena, Calif. Applied loads are localized to reduce the size and number of structural members.

The lightweight, low cost bolt also uses a multistage telescopic piston. This design provides greater acceleration (which can be predetermined) to the jettisoned article by allowing longer strokes. The reaction forces on the remaining structure in this way is held to a minimum. Any desired acceleration can be had by using a smaller force over a greater distance.

When a number of ejection bolts are needed, a synchronizer mechanically insures the simultaneous start of each injection stroke. The start will occur only when a predetermined pressure is reached in each of the breeches. This makes it possible to have different ejection forces during a single separation of several bolts. When a store must be separated from a vehicle with a specified pitching moment, the "two-point synchronized push" will only release and eject at the proper magnitude.

Strokes from ½ to 36 in. are possible. Present designs indicate ejection forces up to 35,000 lb and suspension loads up to 60,000 lb per unit may be handled. The projectile may be held to the pistons by hooks, tongs, sockets, or any similar attachment. An automatic lock in each bolt locks the part to the piston.

The pistons are held to each other and the housing by a series of locking pins spaced evenly about the circumference of the bolt. These pins may be released by gas pressure or manually. After mechanism release, the gas pressure builds up and gives the bolt the thrust needed for separation.

Ultimate suspension loads in the various stores exceed the requirements of Mil-T-8591A. The operating mechanism can perform to Mil-T-7743.

Lubrication is self-contained. It maintains a constant viscosity from −100 to +350 deg F.

The cartridge chamber may be integral with the bolt or, when several bolts are needed, be a separate member.

When it is used separately, gases are piped to each bolt through high strength tubing or a manifold. The various bolt circuits are each designed to exert predetermined ejection forces by varying the number and type of cartridges, the size of the gas escape hold, and the diameter of the piston heads. The forces peak before release and maintain a maximum for about 80 per cent of the stroke.

A safety pin prevents linkage motion. If a premature cartridge firing did occur, the store or part would remain intact.

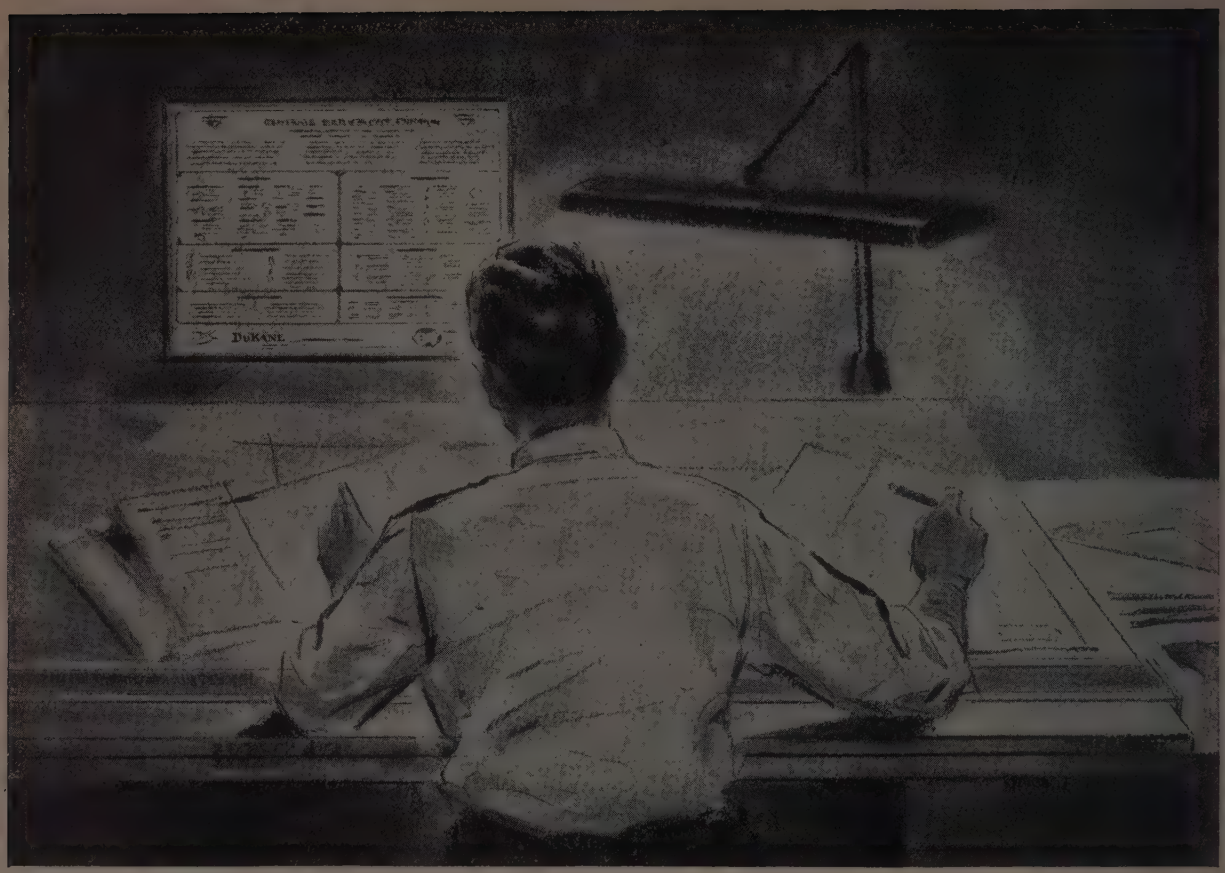
The cartridge may be fired safely with the pistons blocked, the force being absorbed within the unit. A manual release for free fall of the store is also provided. Sway braces may be used as an integral part of the housing.

The synchronizer is the "brain" of the ejection bolt, insuring ejection only at the present pressure level. A time lag may be set into the system to let one unit precede another.

The male and female portions of the bolt may be integral parts of a bulkhead (primarily for the separation of missile sections). For the ejection of cargo, one end of the bolt may be fastened to the floor and the opposite end used as a ram. If an attaching effect is needed but no force ejection, the bolt's motivation action will "break" only the tie.

The bolt weighs only 0.17 lb, yet delivers an ejection of 700 and supports a load of 2500 lb. Overall length is 1⅞ in. (2⅞ in. including synchronizer link), with a major diameter of 7/8 in.

The bolt may be threaded to each of the parts to be separated or attached by an automatic link. It may be installed either in the primary structure or in the part to be separated.



How To Specify Ground Communications For a Missile Base

First, consider the supplier's experience and reputation. DuKane Corporation, pioneer in electronic communication systems, has installed ground communication equipment on such bases as White Sands, Patrick AFB, and Fort Churchill . . . *Second*, get help from an expert. DuKane's engineers are ready to help you. They've had wide experience in all phases of communications, including giving direct help to architects and consulting engineers in designing systems to meet any combination of needs . . . *Third*, consider equipment and flexibility. Of all the manufacturers of voice communication equipment, only DuKane offers a truly complete selection: intercom, public address, paging, background music, private automatic telephone, wireless paging for key personnel, emergency and evacuation systems, and hospital communication systems—in any combination to form an integrated system of any size, a few stations to hundreds.

For missile base ground communications, come to the experts . . . Write or wire DuKane Corporation, Dept. SA-2, St. Charles, Illinois. If you specify electronic equipment, ask also for DuKane's chart of electronic equipment symbols.

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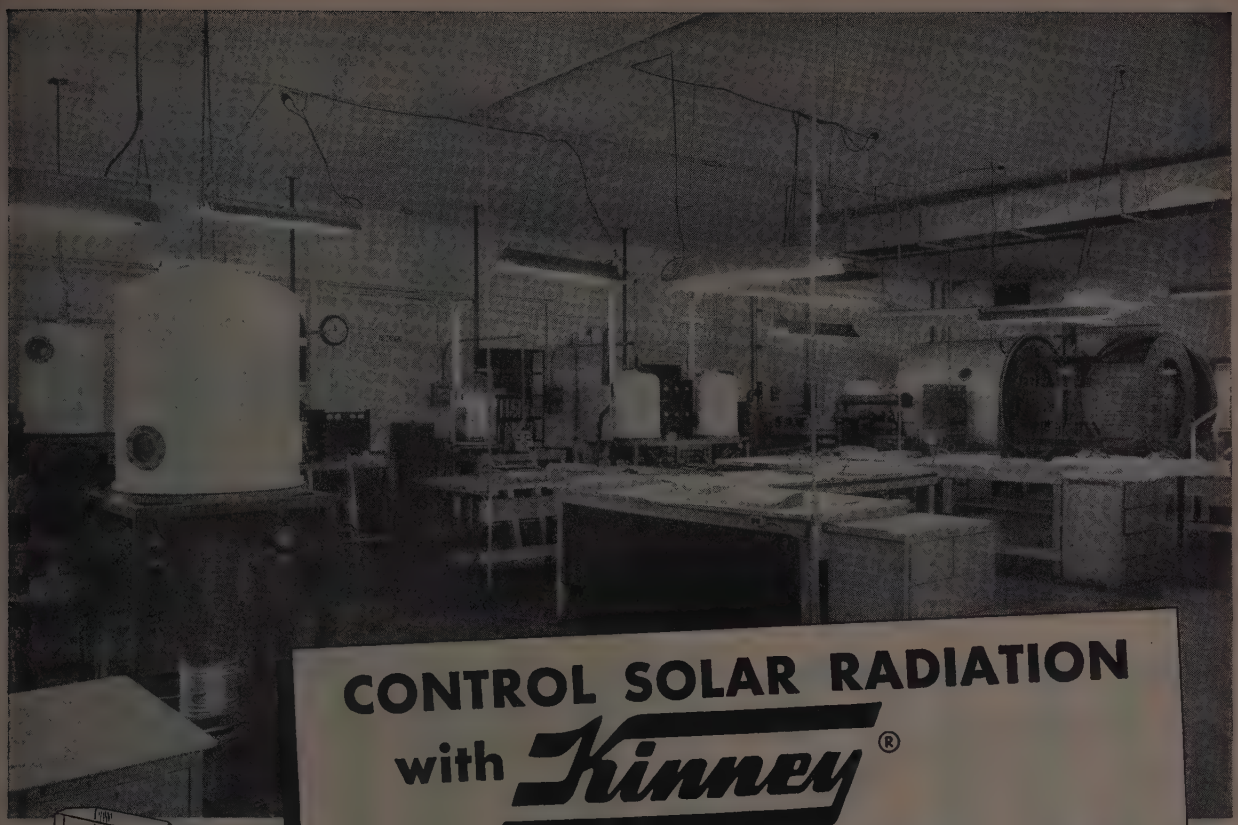
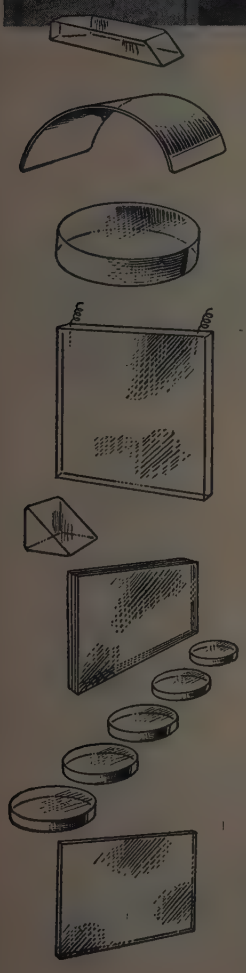


CONTROL SOLAR RADIATION with Kinney® PRECISION EVAPORATED FILMS



The answer to your problems with Solar Radiation may well be found in KINNEY High Vacuum Coatings. Have you explored the possibilities of controlling REFLECTION, TRANSMISSION, ABSORPTION and EMISSIVITY with KINNEY Precision Evaporated Films? Here are advanced techniques, backed by years of research and successful production of optical and electrical films applied to a broad range of surfaces and substances.

DO YOU SEEK PROTECTION OF INSTRUMENTS FROM SOLAR HEAT?

KINNEY offers Infra-red Reflecting Films designed to your specifications . . . can be deposited on Glass, Plastic or Metal . . . and many other materials.

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KINNEY provides precise deposition of films for Dark Mirrors and Beam Splitters as well as Absorbing Films.

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Please send me information on ☐ Mirrors ☐ Low Reflection Films ☐ Infra-red Films ☐ Semi-Transparent Films ☐ Dichroics ☐ Beam Splitters ☐ R.F. Shielding ☐ Have engineer call.

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Company_____

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FOR ELECTRONICS PLANTS...
FOR AIRCRAFT AND MISSILE BASES...

NEW 400-CYCLE BUS DUCT

WITH ONLY 1.28 VOLTAGE DROP PER 100 FT!

High-frequency power distribution runs are, for the first time, really practical and economical. Now, a single, central high-frequency generator can completely power tens of thousands of square feet.

At 400 cycles and up, new Westinghouse high-frequency bus duct will deliver power with a maximum voltage drop of only 1.28 volts each 100 feet under full load of 800 amps. Here is performance that cannot economically be begged, borrowed or coaxed out of cable-conduit or other bus duct. Compare this efficiency with conventional systems in which drops of from 7 to 15 volts can normally be expected. Housing of duct is nonmagnetic aluminum . . . shields test equipment from radio frequencies originating in duct.

Here is an opportunity, too, to take advantage of all the inherent advantages of bus duct. Power taps every 60 inches over the entire length of duct . . . no splicing. No complex wire mazes. Infinitely more flexible and convenient to use. Duct is more quickly and easily installed than cable and conduit.

High-frequency bus duct is immediately available . . . and only from Westinghouse. Get in touch with your local Westinghouse sales representative. Or write or wire Standard Control Division, Westinghouse Electric Corporation, Beaver, Pa. J-30285

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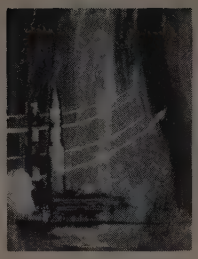

R&D facilities and specialties

Airtech Ltd., Aylesbury and Thame Airport, Haddenham, Bucks., England.

Manufacturing plant: Haddenham Works, 75,000 sq ft floor space.

Research facilities: Haddenham Works, 4,000 sq ft floor space.

Engineering dept.: 40 personnel.

Employment, total: 350 personnel.

R&D specialties: Air transportable containers; mobile telecommunication systems; telemetering equipment; specialized filters.

Major product developments: "Aircon" Air Transportable Containers; Complete Mobile Signal Stations; specialized telemetering equipment and filters.

Future engineering research and development plans: Air transportable containers for wide variety of users.

Foreign licensees: None.

Recent and/or current military contracts: Various mobile installations for Royal Air Force, including D.F., general communications, etc.; telemetering equipment for various drone aircraft.

For technical inquiries: F.S.G. Codling, Managing Director.

Sir W. G. Armstrong Whitworth Aircraft Ltd., Baginton, Coventry, England.

Manufacturing plant: Baginton Factory (Aircraft and Electronics Production) Whitley Factory (Guided Weapons and Research) Bitteswell Factory (Aircraft final assembly), Hangars and test airfield.

Research facilities: Whitley Factory.

Employment, total: About 9,000 personnel.

R&D specialties: Nuclear energy equipment; electronics; manned aircraft (all types); surface-to-air missiles; printed circuits; computers; data handling systems.

Major product developments: Medium range turboprop Freighter-coach aircraft; Car Ferry/Cargo Freighter aircraft; short range (2-pence-a-mile) Airbus; Seaslug ship-to-air missile system; specialized electronics.

Future engineering research and development plans: Space re-entry vehicles; surface-to-air missiles; atomic energy equipment.

Foreign licensees: In Germany.

Recent and/or current military contracts: Hawker Hunter fighters; Sea Hawk naval fighters; Javelin A.W. fighters; Seaslug missile; Meteor T.T. 20 target towing aircraft.

For technical inquiries: C. S. Emery, Sales Director.

B.B. Chemical Co. Ltd., Ulverscroft Road, Leicester, England.

Manufacturing plant: Mills and churns for production of rubber adhesives; batteries of mixers for adhesives blending; equipment for Latex adhesives blending; complete facilities for compounding, packaging and shipping of leather finishes; facilities for manufacture of hot melt adhesives, sealing compounds and consumer adhesives.

Research facilities: Series of laboratories.

Employment, total: 750 personnel.

R&D specialties: Adhesives, sealants and coating compounds for aircraft.

Major product developments: For aircraft: integral fuel tank sealing; interfaying sealants for pressurized fuselages; de-icer shoe adhesives; sealants for observation windows; rain-erosion adherents.

Future engineer research and development plans: To keep pace with demands of aircraft industry for adhesives capable of withstanding extreme temperatures and speeds.

Foreign licensees: None. (Associated with B.B. Chemical Co., Cambridge, Mass., U.S.A.; B. B. Chemical of Canada Ltd.; Compagnie de Produits Chimiques "Boston", France; Boston Blacking Co., G.m.b.H., Germany; Compania de Tintas Boston, S.A., Spain; B. B. Chemical Co. A/B, Sweden. Also supervise: B. B. Chemical Co. (Ireland) Ltd.; B.B. Chemical Co. of Australia PTY. Ltd.; B.B. Chemical Co. of New Zealand Ltd.; B.B. Chemical (So. Africa) PTY. Ltd.

For technical inquiries: F.D. Cameron, Sales Manager.

Belling & Lee Ltd., Great Cambridge Rd., Enfield, Middlesex, England.

Manufacturing plant: Three factories (general light engineering).

Research facilities: Complete, with all necessary modern testing facilities.

Engineering dept.: 500 personnel.

Employment, total: 1200 personnel.

R&D specialties: Electronic component reliability, etc.

Major product developments: Single and multiple plugs, sockets, connectors, fuses, fuseholders, circuit protection devices, R.F. and VHF plugs, etc. Printed circuit components transistor and other seals.

Future engineering research and development plans: Higher temperature and lower pressure components.

Foreign licensees: Australia and France.

Blackburn & General Aircraft Ltd., Brough, East Yorks., England.

Manufacturing plant: Head office and Works Brough East York's. Scottish Works, Castle Rd., Dumbarton, Scotland.

Engineering Dept.: 1,500 personnel.

Employment, total: 4,000 personnel.

Recent and/or current military contracts: NA.39 (low level naval strike jet aircraft; starter units employing small gas turbines for Royal Navy, RAF and RCAF; gas turbines for helicopters).

For technical inquiries: Air Vice Marshal H. N. Thornton.

Boulton Paul Aircraft Ltd., Wolverhampton, England.

Manufacturing plant: Wolverhampton —modern factory, equipped with up-to-date high precision machinery.

Research facilities: Fully equipped for structural, aerodynamic hydraulic, electronic and chemical research.

Major product developments: Military aircraft; powered flying controls.

Foreign licensees: None.

For technical inquiries: F. F. Crocombe. Dir. & Chief Engineer.

Bristol Aircraft Ltd. (subsidiary of Bristol Aeroplane Co. Ltd.), Filton House, Filton, Bristol, England.

Manufacturing plant: Filton Factory, 2,000,000 sq ft floor space. Fixed and rotary wing aircraft (excluding engines and props, including 'copter transmis-

more on next page

THE NEW

KLIXON

Micro-Miniature Circuit Breaker for Aircraft, Radio and Electronic Equipment

These *Micro-Miniature* KLIXON D7274-1 Circuit Breakers set new standards in size, weight and performance. Their *fast tripping response* provides protection for low thermal mass components used in aircraft, radio and electronic gear.

Configurations are available for installation in existing panels that accommodate the NAF-1357 panel-mounted fuses or larger neck-mounted miniature circuit breakers. To give remote indications (light or buzzer), a normally open auxiliary circuit can be provided.

Compare these features . . .

- Weight 0.9 oz.
- Extremely simple trip-free design . . . no reset possible while button is depressed.
- Maximum operating force — open and reset 5 lbs.
- Minimum and maximum limits of ultimate trip (25°C) — 115% minimum, 150% maximum.
- Overload calibration — 200% trip limits 15 seconds maximum.
- Operating altitude — 80,000 ft.
- Voltage drop maximum — 1.50 volts.
- High rupture capacity — tests over 4000 amperes, 120 VAC.
- Ratings — ½ to 5 amperes.

Send for complete information on this new KLIXON *Micro-Miniature* Circuit Breaker, today.

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A DIVISION OF TEXAS INSTRUMENTS INCORPORATED

SPENCER PRODUCTS

Klixon® Inherent Overheat Motor Protectors • Motor Starting Relays

Thermostats • Precision Switches • Circuit Breakers

Western Manufacturers — refer inquiries directly to Metals & Controls Corporation, Southern California Office . . . 232 North Lake Ave., Pasadena, Calif., Tel: Ryan 1-4288.

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sions); missile airframes and plastic structures. Modification and overhaul or repair of civil and military aircraft can be done. Weston-super-Mare Factory, 350,000 sq ft floor space. Design, development, production of single and tandem rotor 'copters. Test rigs and flight test for both types. Cardiff Factory. Ground-to-air guided missiles.

Research facilities: Very comprehensive, commensurate with field of aeronautics covered by company, available at all three plants.

Employment, total: 11,000 approx.

R&D specialties: Guided missiles and weapon systems. Tandem rotor 'copters. Heavy transport and cargo aircraft. Supersonic aircraft. Structure research and development. Plastics. Electronics.

Major product developments: Britannia turboprop transport. 192 tandem rotor 'copter. Bloodhound ground-to-air guided weapon. 188 all steel supersonic development aircraft. Electronic recording, inspection and research equipment. Wide range of high precision plastics.

Future engineering research and development plans: Classified military projects. Civil medium range turbojet transports. Helicopters. Large turboprop cargo plane.

Foreign licensees: Canadair Ltd., Montreal, Canada (CL 28 and 44 aircraft)

Recent and/or current military contracts: Bloodhound for RAF and Sweden. Britannia for RAF Transport Command. Sycamore 'copters, for RAF and W. German AF. 192 twin-gas turbine 'copter for RAF. Plastic drop tanks, pressure vessels for RAF and NATO.

For technical inquiries: The Manager, Sales Engineering Dept.

Bristol Siddeley Engines Ltd., Ormonde House, 26/7 St. James's St., London, S.W. 1, England.

Manufacturing plant: Bristol, Coventry and elsewhere, 5,000,000 sq ft, includes research.

Employment, total: 27,000 personnel.

R&D specialties: Ramjets, rocket engines, turbojets (with and without after-burning), turboprops, piston engines. Nuclear energy.

Major product developments: Ramjets (for guided weapons); rocket engines; Olympus, Sapphire, Orpheus and Viper turbojets; Proteus, Double Mamba and P.181/182 turboprops and turboshaft engines.

Future engineering research and development plans: Classified, except development of most of above engines.

Foreign licensees: Curtiss-Wright Corp., U.S.A. (J65 Sapphire); Fiat, Italy; Hindustan Aircraft Ltd., India; SNECMA, France.

Recent and/or current military contracts: Thor ramjets for Bloodhound for RAF and Sweden; Olympus for RAF Vulcan bomber; Sapphire for RAF Victor bomber; Orpheus for RAF Gnat trainers and NATO lightweight strike fighters; Viper for RAF Jet Provost trainers. A. S. "Gamma" engine for Black Knight.

For technical inquiries: Sales Manager (Bristol Aero-Engines Ltd., Filton House, Bristol; or Armstrong Siddeley Motors Ltd., Coventry.

S. G. Brown Ltd. (Incorporating The

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COMMAND DESTRUCT

The flight testing of second generation missiles—more versatile and powerful than their predecessors—requires a device for sure termination of any missile flight that might endanger the test range or surrounding area.

Ramo-Wooldridge engineers, under a United States Army Signal Corps contract, have successfully developed and delivered the first sub-miniature, completely transistorized radio "command destruct" receivers.

Specifically designed for missile flight safety operations, the receiver (AN/DRW-11) can actuate safety mechanisms or destruct devices. It has three command channels, each of which actuates a control relay.

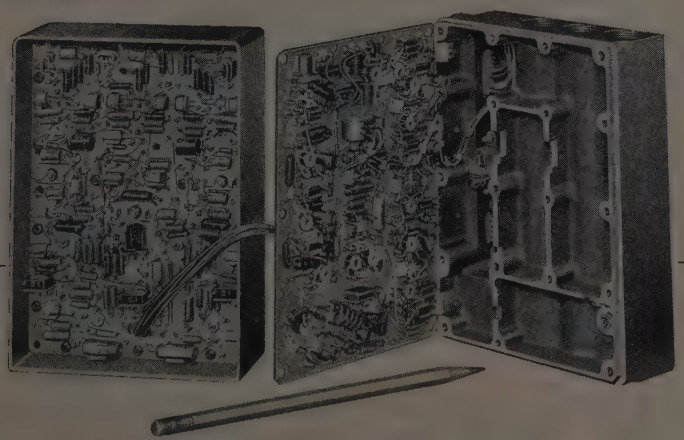
The "command destruct" receiver accepts frequency modulated signals in the UHF radio command control band. It is designed to operate with closer radio frequency and command frequency channel spacing than has been used to date, thus making possible more efficient use of the available radio spectrum.

Compact and rugged, the radio receiver's modular construction permits rapid and complete accessibility to all components. One module houses the basic receiver. The second module contains the three command channels and relays. This integrated package occupies 115 cubic inches, and weighs 4 pounds. The receiver requires no pressurization and operates reliably under the adverse environmental conditions encountered in missile flight testing.

Engineers and scientists interested in being associated with some of the nation's most advanced research and development programs are invited to acquaint themselves with current opportunities at Ramo-Wooldridge. The areas of activity listed below are those in which R-W is now engaged and in which openings exist.

Missile electronics systems
Advanced radio and wireline communications
Information processing systems
Electronic language translation
Anti-submarine warfare
Air navigation and traffic control
Analog and digital computers
Infrared systems
Electronic reconnaissance and countermeasures
Basic and applied physical research

For a copy of our brochure, *An Introduction to Ramo-Wooldridge*, or other additional information write to Mr. Donald L. Pyke.



RAMO-WOOLDRIDGE

P. O. BOX 90534, AIRPORT STATION • LOS ANGELES 45, CALIFORNIA

a division of ***Thompson Ramo Wooldridge Inc.***

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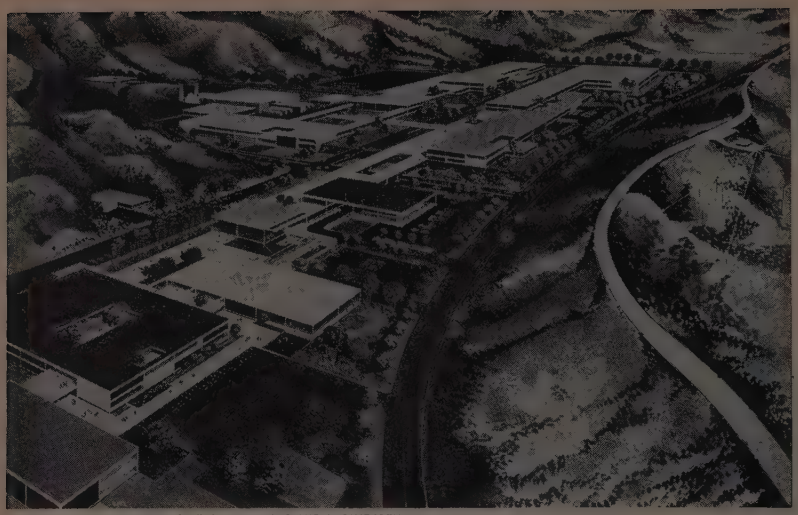

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LOCKHEED'S
New Multi-Million Dollar
RESEARCH CENTER

This project—destined to rank with the world's largest and most advanced Research Centers—represents not only substantial faith but a substantial investment in the future of space flight.

The new Center, now under construction near Los Angeles, will provide facilities for: Exploration of complex technological space requirements; scientific latitude and freedom; ideal environment for research; and the most modern laboratory tools available. Qualified scientists and engineers will find here ground-floor opportunities for extending man's knowledge beyond the present state of the art.

On completion, most of Lockheed's California Division's research facilities will be located in this single area. The Center will provide advanced research facilities in all fields related to atmospheric and space flight including: Propulsion, physiology, aerodynamics and space dynamics; advanced electronics in microwave propagation and infrared; acoustics; mechanical and chemical engineering and plasma/magnetohydrodynamics; thermal electricity; optics; data communications; test and servomechanisms.

Top-level scientists and engineers are invited to investigate outstanding career opportunities for your future in the new Lockheed Research Center. There are openings now for qualified personnel in: Electronics; aero and thermo dynamics; propulsion; servomechanisms; materials and processes; structures and stress; operations research; research in optics, infrared, acoustics, magnetohydrodynamics, instrumentation, mechanics and hydraulics; mathematics; and in all phases of design.

Please direct your inquiry to: Mr. E. W. Des Lauriers, Manager Professional Placement Staff, Dept. 1906, 2400 N. Hollywood Way, Burbank, Calif.

LOCKHEED
CALIFORNIA DIVISION
BURBANK, CALIFORNIA

Check Employment Inquiry Form on Page 153

Submarine Signal Co. (London) Ltd., Shakespeare St., Watford, Herts., England).

Manufacturing plant: Precision and commercial engineering equipment. Precision gear cutting plant. Coil winding; instrument manufacture and assembly. Air Registration Board approved.

Research facilities: ARB approved air conditioned research and acoustic labs. Wide range of temperature, pressure and humidity test equipment.

Engineering dept.: 400 personnel. (U.K.)

Employment, total: 1100 personnel (U.K.)

R&D specialties: All types electromechanical equipment. Precision instruments for land, air, marine use. Azimuth, rate and north-seeking gyroscopic equipment. Transistor application.

Major product developments: North-seeking and heading reference gyros. Marine auto-helmsmen. All types earphones and telephones. Central dynamic reference systems for aircraft, guided weapons equipment, other classified military products.

Future engineering research and development plans: All types precision servo systems with wide operating temperature range. Transistorized servo amplifiers. Miniature north-seeking and heading reference gyros. Central dynamic reference systems, other aircraft instruments for military, commercial use; acoustical research.

Foreign licensees: S. G. Brown (Canada) Ltd., Montreal, Quebec, Canada (subsidiary); Association des Ouvriers en Instruments de Precision, Paris, France; Les Laboratories de Physique Applique, Paris, France; American Bosch Arma Corp., Garden City, N.Y. (associated).

Recent and/or current military contracts: Guided weapon equipment; central dynamic reference system for supersonic aircraft; airborne radar and vehicle armament stabilizing system; submarine automatic depth and course control equipment; submarine detecting equipment.

For technical inquiries: J. Crampton, Air Liaison Executive.

Contraves A.G. Zurich, 580 Schaffhauserstrasse, Zurich 52, Switzerland.

Manufacturing plant: Zurich, 176,000 sq ft floor space; Rome, 170,000 sq ft floor space.

Research facilities: Special climate and test rooms; vibrators; cold, heat, humidity, tropical rain, sand storm, drop tests. Facilities at company disposal: 1 wind tunnel in Zurich; 1 wind tunnel in Emmen.

Engineering dept.: 450 personnel (Zurich only)

Employment, total: 920 personnel

R&D specialties: Guided missiles: fire control systems; automatic controls; analog computers.

Major product developments: Type RSC and RSD anti-aircraft missile; Mosquito anti-tank weapon; fire control units.

Future engineering research and development plans: Type RSE anti-aircraft missile; miniaturized fire control units.

Foreign licensees: 9 licenses in 7 countries.

For technical inquiries: Dr. Ing. A. Gerber, President.

more on page 182

ROCKET ENGINES

NEW tungsten linings for rocket nozzles . . .

MELTING POINT: 6170°F.

Tungsten-lined lightweight nozzles for solid propellant engines are now being fabricated by General Electric. With a lining melting point of 6170°F, these are among the highest temperature lightweight fixed and flexible nozzles in use in the missile industry, enduring high rocket propellant temperatures and pressures with no measurable erosion.

These nozzles are produced by an arc-spraying process pioneered by General Electric. Tungsten is vaporized in an arc and deposited on a mandrel. For some applications, the liner is molded in lightweight plastic, and the mandrel leached out.

Arc-sprayed nozzles have been hot-fired with the new high temperature propellants at several locations.

G.E.'s capabilities in metallurgy and manufacturing are combined with equally advanced capabilities in engineering, research and development. Integrated advanced rocket engine capabilities at General Electric can meet your needs for high performance solid propellant engine cases, nozzles and liquid engine components using cryogenic and storeable propellants.

Progress Is Our Most Important Product

GENERAL ELECTRIC

The Flight Propulsion Laboratory Department's Rocket Engine Section is the nucleus of General Electric progress in rocket engines and their components. It is well-equipped; and it uses Company-wide capabilities and experience to speed advances. If you would like more information about the section's products and capabilities in solid or liquid propulsion systems, please mail this coupon. Rocket Engine Section, General Electric Co., Cincinnati 15, Ohio.

Section A182-2
Rocket Engine Section
Flight Propulsion Laboratory Department
General Electric Company
Cincinnati 15, Ohio

Please send me additional information about General Electric solid propellant cases and nozzles (GED-3763). ☐

I would like to discuss G-E rocket engine products with a sales representative. ☐

Name.....
Title.....
Company.....
Address.....
City..... **State**.....

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Write in No. 120 on Reader Service Card at start of Product Preview Section

SS.10 SS.11

The guided missiles manufactured in mass production by

NORD-AVIATION

2 à 18, RUE BÉRANGER • CHATILLON s/s BAGNEUX
SEINE - TÉL. ALÉSIA 57-40

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R&D FACILITIES . . .

John Curran Ltd., Curran Road, Cardiff, Glam., U.K.

Manufacturing plant: Works, 50,000 sq ft floor space; Packing & Joinery Dept., 16,000 sq ft floor space. Works equipped with all types of machine tools and sheet metal machinery.

Research facilities: One aircraft engine test house.

Engineering dept.: 200 personnel.

Employment, total: 280 personnel.

R&D specialties: Test equipment for all types of aircraft engines. Centrifugal testing machines (G-testing for electronic parts up to 40g). Neutron diffraction spectrometer for atomic research.

Major product developments: Test facilities for engines powering Vickers Vanguard, Viscount; Boeing 707, Douglas DC-8; Lockheed Electra.

Future engineering research and development plans: Continued R&D of test facilities for aircraft engines of future.

Foreign licensees: None.

Recent and/or current military contracts: New 30,000-lb static thrust test facility for Royal Navy. Complete jet and turboprop test facilities for Rolls-Royce of Brazil; turboprop test installation for Mid-East Aircraft Servicing Co.; turboprop test installation for Continental Airlines, Denver, Colo.; neutron spectrometer for atomic research establishment in India, Germany, Sweden.

For technical inquiries: T. E. Curran, Director.

The de Havilland Aircraft Co. Ltd., Hatfield Aerodrome, Herts., England.

Manufacturing plant: Hatfield, approx. 1,000,000 sq ft floor space; Chester, approx. 1,000,000 sq ft floor space; Portsmouth (subassemblies); Christchurch (military and naval)

Research facilities: Wind tunnels (high and low speed); maths. service section; instrument labs; materials labs; structural test; functional and flight test.

Major product developments: AIRCO D.H.121 600-mph 100 passenger jet airliner, short and medium haul ranges, for 1964 service.

Foreign licensees: Hindustan Aircraft (Private) Ltd., India; The Commonwealth of Australia (D.H. Australia); Sud Aviation, France; SICMAR, Italy; OGMA, Portugal; Service Technique Militaire, Switzerland; Egyptian Government.

Recent and/or current military contracts: Vampire trainers (Venezuela); Vampire trainer fuselages (Sweden); Sea Vixen all-weather fighters, for Royal Navy; Comet 2 for RAF Transport Command; long range ballistic missile (in association with de Havilland Propellers Ltd.)

For technical inquiries: Publicity Manager (first contact).

The de Havilland Engine Co. Ltd., Leavesden, Herts., England.

Manufacturing plant: Leavesden gas turbine works.

Research facilities: Leavesden, gas dynamics labs, turbine test beds. Harlow, rocket engine development.

Major product developments: Gyron, Gyron Jr., rocket engines.

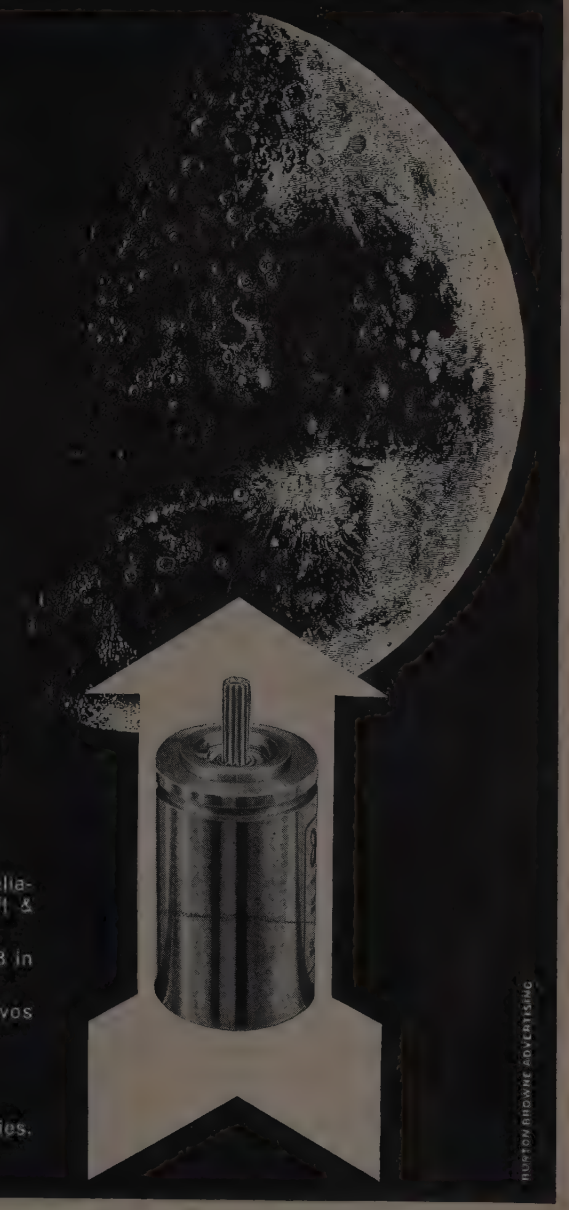
Future engineering research and development plans: rocket engines.

For technical inquiries: John Scott.

more on page 184

Oster®

to the Outside



MISSILE QUALITY SERVOS

For trouble-free systems, missile designers specify Oster reliability. Choose from the Complete Line for Missile, Aircraft & Ground Support Applications.

- Sizes 8, 10, 11, 15, 18, 23, 29 in 400 cycle. Sizes 15, 18, 23 in 60 cycle.
- −55° to +125°C temperature range. Higher temperature servos available for special applications.
- Meet MIL-E-5272A & MIL-E-5400.
- Available with leads & terminals to your requirement.
- Immediate delivery from stock of many types in sample quantities.

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NEW 24-page SERVO MOTORS CATALOG No. 5000

Lists 40 basic servo types for military, scientific and industrial applications. Write for your free copy on company letterhead today.

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NEW YORK OFFICE — 237 North Main Street, Hempstead, L.I., New York. Phone: Ploneer 2-4552. TWX: Hempstead N. Y. 1441

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WESTERN OFFICE — 5333 So. Sepulveda Blvd., Culver City, California. Phone: EXmont 1-5742; Ieyes 0-1194. TWX: S. Mon 7671

Engineers For Advanced Projects: Interesting, varied work on designing transistor circuits and servo mechanisms. Contact Mr. Robert Burns, Personnel Manager, in confidence.

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THIS ENGINEER WAS A VICTIM OF MULTIPLE-DESK ROWS

Maybe *you* know his symptoms: a growing belief that you're not really needed, a sense of being chained publicly to your station, a feeling that you're a cipher in a long row of digits.

Luckily, for he was just about ready to flip entirely, he found out about RCA Service Company—saw that here is an organization that needs your ability, not just your presence. He discovered RCA's "break-through" assignments—met "hotshot" specialists who could really help him to learn. Best of all, he found he could apply his theoretical concepts to projects right in the field—could see a job through from start to finish. So he came over to RCA Service Company, and he's been happy ever since. No more multiple-desk rows for *him!*

Like to do the same? If you're an electrical or mechanical engineer with a desire to go places, send a résumé to: Mr. James Bell, Employment Manager, Dept. Y-19F, RCA Service Company, Cherry Hill, Camden 8, N. J.

EQUAL JOB OPPORTUNITY All Qualified Applicants

RCA SERVICE COMPANY

A Division of Radio Corporation of America

Check Employment Inquiry Form on Page 153

R&D FACILITIES

The de Havilland Propellers Ltd., Hatfield, Herts., England.

Manufacturing plant: Hatfield, and three factories in north of England, total, approx. 1,500,000 sq ft floor space.

Research facilities: Large stratospheric chamber, comprehensive vibration labs; other facilities commensurate for producing propellers, missiles, electronics.

Engineering dept.: 2500 personnel.

Employment, total: 9000 personnel.

R&D specialties: Servo systems; gyros; torque motors; vibration analysis.

Major product developments: British long range ballistic missile; Firestreak air-to-air missile; propellers; radar scanners; lightweight alternators; plastics; aircraft airconditioning systems; fuel control systems.

Foreign licensees: E.N.H., Spain (propellers)

Recent and/or current military contracts: Firestreak AAM for RAF and Royal Navy; British long range ballistic missile (Bluestreak); propellers for Canadair CL-44; alternators for Bloodhound and Seaslug missiles; cold air units for Victor, Scimitar, Lightning.

For technical inquiries: J. A. Airey.

Dowty Fuel Systems Ltd., Alre Court, Cheltenham, Glos., England.

Manufacturing plant: Cheltenham Works and associated manufacturing companies.

Research facilities: Engine test bed. Complete test and analysis equipment for fuel sprays, fuel pumps and fuel system controls.

R&D specialties: Complete fuel control systems and associated units for gas turbine engines.

Major product developments: Complete fuel system and pumps for current British production engines.

Future engineering research and development plans: Fuel control and associated equipment for military and commercial gas turbines, ramjets and rocket motors.

Foreign licensees: Thompson Products, Inc., USA; Parker Hannifin Corp., USA.

Recent and/or current military contracts: Complete fuel control system for Gyron Jr engine. Fuel system controls and control units for classified projects.

For technical inquiries: F. H. Carey, Director.

Elliott Brothers (London) Ltd., Radar Division, Elstree Way, Boreham Wood, Herts., England.

Manufacturing plant: 12,000 sq ft floor area.; manufacturing printed circuits; transformers; sheet metal fabrication and wiring assembly.

Research facilities: 4,000 sq ft floor area, plus aerial test site.

Engineering dept.: 45 personnel.

Employment, total: 120 personnel.

R&D specialties: 8 mm and 1.8 cm wavelength radar systems and components; subminiature special purpose analog computers.

Major product developments: 8 mm wavelength ranging radar; 8 mm wavelength auto-tracking radar system. Licensed manufacture of wide range of Bendix Radio products including VHF communication and navigation equipment; radio compass; weather radar; UHF communication equipment; selec-

more on page 188

Now 4 CHR High Temperature TEFLON® Tapes

Temp-R-Tape adheres securely to bar heated to 520°F during high temperature resistance test.

Pressure-Sensitive TEFLON Tapes

easy to apply in both electrical and mechanical applications

The electrical uses of Temp-R-Tape include slot lining, interlayer and interphase insulation, harness bundling, wrapping for microwave components, transformer coils, capacitors and high voltage cables, etc.

As a low friction, non-stick facing, Temp-R-Tape applications range from facings for film guides in sensitive electronic instruments to the facing for heat sealing bars, forming dies, chutes, guide rails, etc.

Chemical resistant facing applications include masking tape in high temperature dipping operations.

All four of these pressure-sensitive Teflon tapes are available from stock in rolls and in sheet form. In addition to Teflon tapes, CHR also makes a fiberglass tape with thermal curing, pressure-sensitive silicone adhesive (Temp-R-Tape GV) and silicone rubber coated fiberglass tape with thermal curing, pressure-sensitive silicone adhesive (Temp-R-Tape SGV).

FREE SAMPLES and folder — write, phone or use inquiry service.

— −100°F to 500°F applications

— Class H and Class C insulation

— Non-stick and low friction facing

— Chemical resistant facing

TEMP-R-TAPE T is a .006″ pressure-sensitive Teflon tape with −100°F to 400°F (−70°C to 200°C) temperature range. It has high dielectric strength, low power factor, negligible moisture absorption, high elongation, is non-corrosive and non-contaminating. Meets Class H Temperature requirements.

TEMP-R-TAPE TH is a .013″ pressure-sensitive Teflon tape with −100°F to 400°F temperature range. It is similar to Temp-R-Tape T except that it is made of .010″ Teflon film to which .003″ silicone polymer adhesive has been added. Often used where a single, thicker dielectric barrier is desired or where a more rigid, abrasion resistant wrap is required.

TEMP-R-TAPE C is a .002″ pressure-sensitive, thermal curing Teflon tape with −100°F to 500°F temperature range. It is made with a cast Teflon film which provides dielectric strength (2750 v/m) higher than any other type of Teflon film. When cured in place, it will operate at temperatures up to 500°F and will withstand much higher temperatures for short periods. Meets Class H and Class C temperature requirements.

TEMP-R-TAPE TGV is a thermal curing, pressure-sensitive Teflon impregnated fiberglass tape with −100°F to 500°F temperature range. Although it is used extensively for mechanical and electrical applications, its dielectric strength is lower than other Temp-R-Tapes.

CHR products include:

COHRlastic Aircraft Products — *Airframe and engine seals, firewall seals, coated fabrics and ducts*

COHRlastic Silicone Rubber Products — *Silicone rubber moldings and extrusions, silicone rubber sheets, silicone sponge rubber*

Temp-R-Tapes — *Pressure sensitive, thermal curing Teflon and silicone tapes*

Allied Products — *COHRlastic silicone cements and conductive gasketing*

CHR

Leader In Fabrication of Silicone Rubber

CONNECTICUT HARD RUBBER COMPANY

Main Office: New Haven 9, Connecticut

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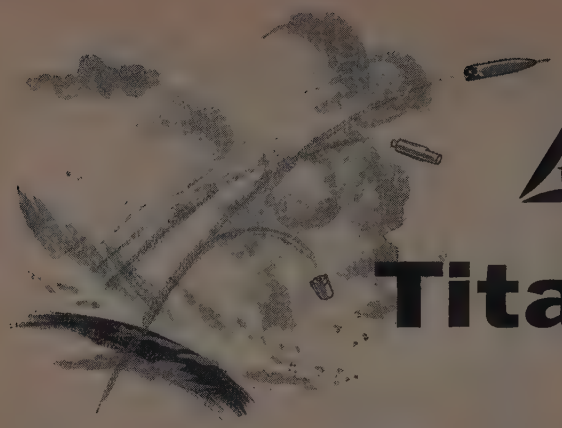
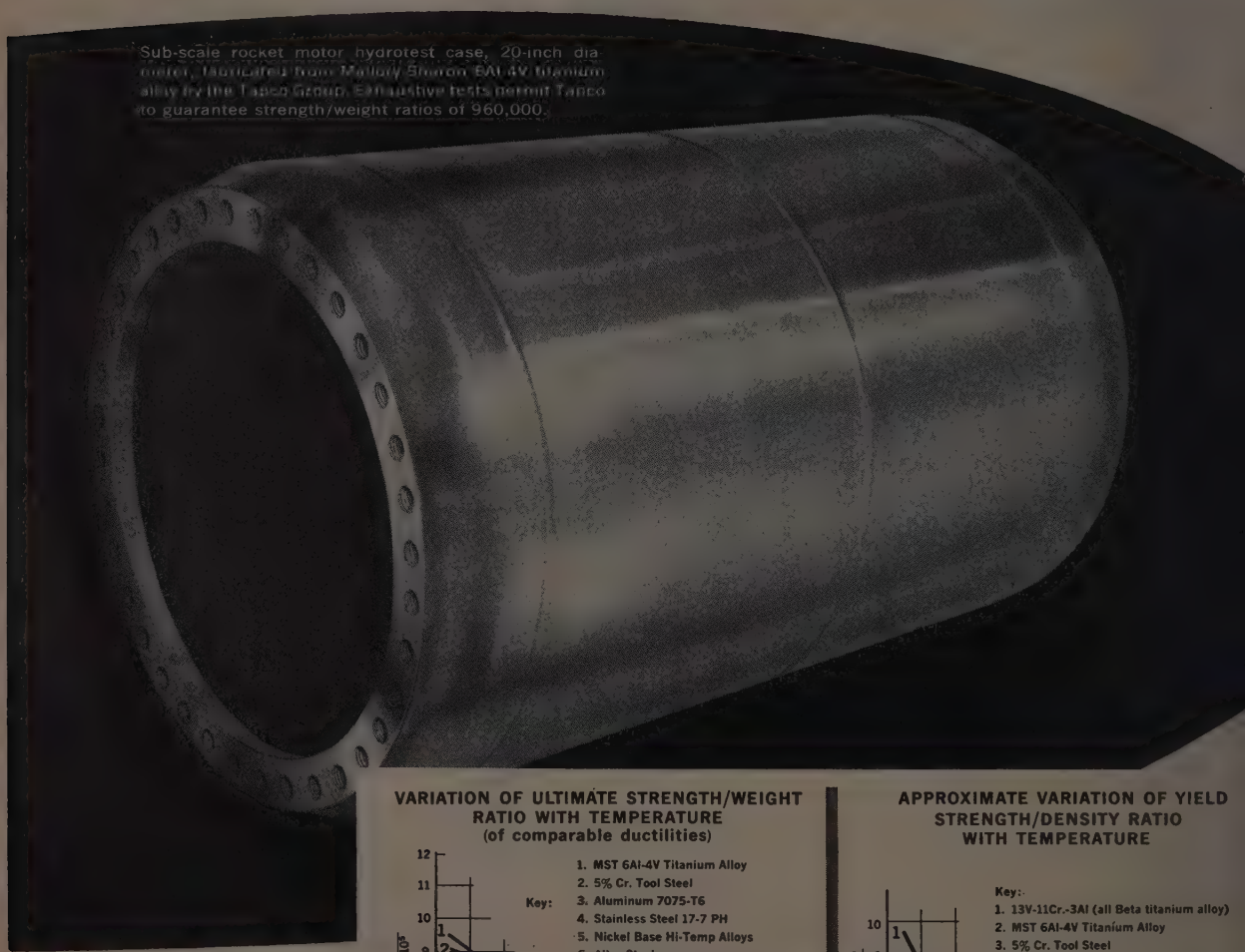


TRW

Tapco develops test-proved

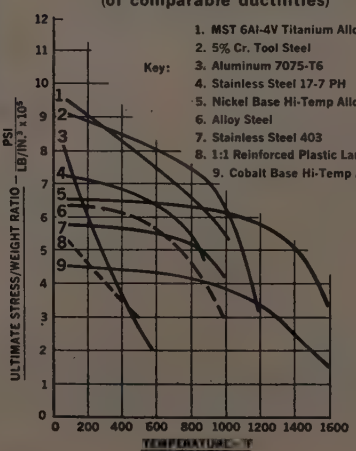
Titanium rocket

...with guaranteed tensile

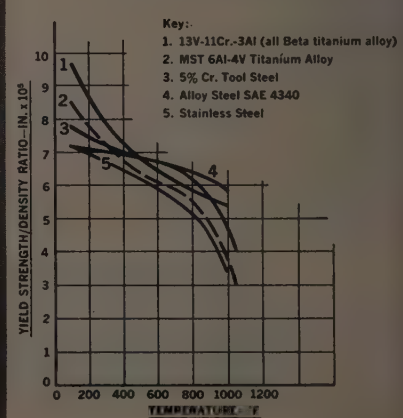


Sub-scale rocket motor hydrotest case, 20-inch diameter, fabricated from Mallory Sharon 6Al-4V titanium alloy by the Tapco Group. Exhaustive tests permit Tapco to guarantee strength/weight ratios of 960,000.

VARIATION OF ULTIMATE STRENGTH/WEIGHT RATIO WITH TEMPERATURE
(of comparable ductilities)


ULTIMATE STRESS/WEIGHT RATIO — PSI / LB/IN.³ x 10⁵
TEMPERATURE — °F
0 200 400 600 800 1000 1200 1400 1600
0 1 2 3 4 5 6 7 8 9 10 11 12
Key:
1. MST 6Al-4V Titanium Alloy
2. 5% Cr. Tool Steel
3. Aluminum 7075-T6
4. Stainless Steel 17-7 PH
5. Nickel Base Hi-Temp Alloys
6. Alloy Steel
7. Stainless Steel 403
8. 1:1 Reinforced Plastic Laminate
9. Cobalt Base Hi-Temp Alloys

APPROXIMATE VARIATION OF YIELD STRENGTH/DENSITY RATIO WITH TEMPERATURE

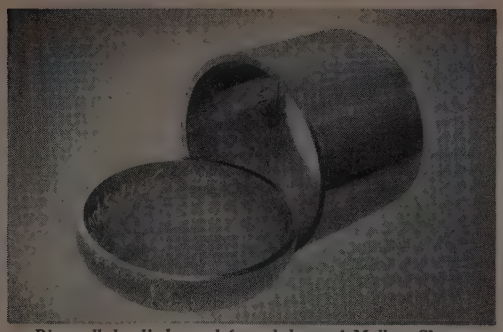

YIELD STRENGTH/DENSITY RATIO — IN. x 10⁴
TEMPERATURE — °F
0 200 400 600 800 1000 1200
0 1 2 3 4 5 6 7 8 9 10
Key:
1. 13V-11Cr.-3Al (all Beta titanium alloy)
2. MST 6Al-4V Titanium Alloy
3. 5% Cr. Tool Steel
4. Alloy Steel SAE 4340
5. Stainless Steel

Titanium tops in Tapco Group's Tests

(Test data courtesy of Thompson Ramo Wooldridge)

motor case

strength/weight ratio of 960,000



Ring rolled cylinder and formed dome of Mallory-Sharon 6Al-4V titanium alloy.

Finish machined 6Al-4V titanium alloy dome and cylinder.

New, advanced type, solid-fuel propellants . . . plus the need to achieve maximum range . . . demand an entirely new look at tensile strength/weight ratios in missile components. For example, designers can no longer tolerate rocket cases whose inert mass approximates 20% of total unit weight. Today's goal: hold rocket-case weight to *less than 10%* of propellant weight.

To achieve this goal, tensile strength/weight ratios of close to 1,000,000 are required in the rocket case. In this range, welded heat-treated steels develop severe embrittlement and high notch sensitivity when subjected to rocket case hoop stresses — largely ruling out their use. Titanium overcomes these disadvantages, plus giving *a weight saving of 25% to 38% over the best competitive steels!*

Tungsten arc inert gas welding of titanium dome to cylinder (final pass).

Extensive development work and testing by the Tapco Group of Thompson Ramo Wooldridge has conclusively proved Mallory-Sharon 6Al-4V titanium alloy to be the most suitable material for this application (see charts at left). It provides the necessary strength and ductility without embrittlement or distortion. It can be readily welded and age hardened to give the welded strength/weight levels required. In view of titanium's outstanding advantages and continuous reductions in cost, any price difference becomes insignificant.

Thompson's excellent experience with MST 6Al-4V titanium alloy enables this leading component parts producer to *guarantee* performance and strength ratios of its titanium rocket motor cases . . . in sizes up to 60" diameters, 20-ft. lengths.

Here's important proof of titanium's growing advantages in missile applications . . . and of Mallory-Sharon's ability to furnish material to meet the most exacting quality specifications. For technical information or application assistance write to: Aircraft & Missile Development Dept., Mallory-Sharon Metals Corporation, Niles, Ohio.

MALLORY SHARON

MALLORY-SHARON METALS CORPORATION • NILES, OHIO

Integrated producer of Titanium • Zirconium • Special Metals

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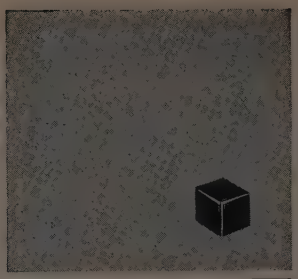
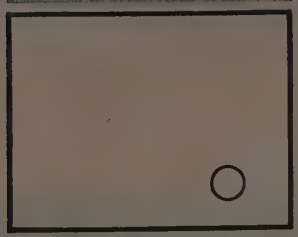
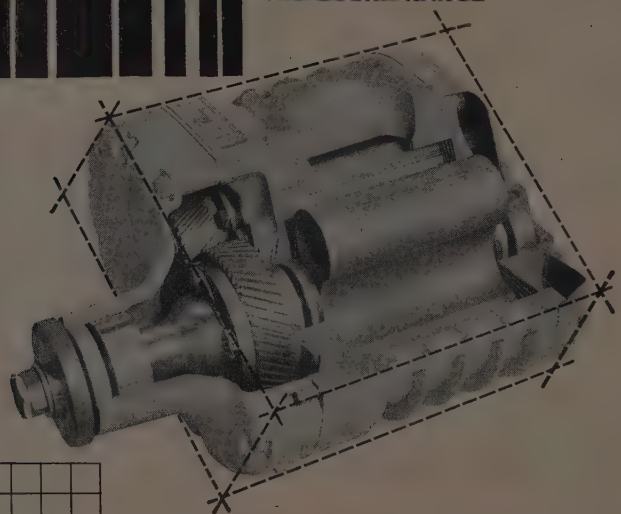


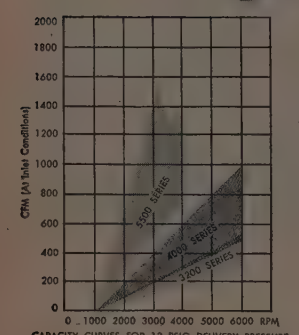
SMALLEST CUBE DIMENSIONS



LIGHTEST WEIGHT

WIDEST PRESSURE RANGE





CAPACITY CURVES FOR 12 PSIG DELIVERY PRESSURE

WITH M-D 3-LOBE BLOWERS

If space and weight of the blower is a concern in your design problem, consider this fact. M-D rotary positive blowers because of their unique 3-lobe design require smaller cubic space than any other blowers. A survey shows that a 14 PSI M-D takes 3/4 to less than 1/10 the space of competitive models . . . and in some cases are only 1/10 the weight.

M-D Blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 11 production models range from 50 to 4000 CFM, pressures to 14 PSIG single, 70 PSIG multi-stage.

For full information write

M-D BLOWERS, INC., RACINE, WISCONSIN

A Subsidiary of Mlehle-Goss-Dexter, Inc.

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tive calling systems, etc. Licensed manufacture of radio compass from Air Equipement, France.

Future engineering research and development plans: Subminiature radar systems on 8 mm and 1.8 cm wavelength; new aircraft navigation and communication equipment.

Foreign licensees: None.

Recent and/or current military contracts: 8 mm fully automatic fire control radar and computer; 8 mm ranging radar; 8 mm radar for missile control; 10 cm missile transponder.

For technical inquiries: W. E. Titmuss, Sales Manager.

English Electric Co. Ltd., Aircraft Div., Warton, Preston, Lancs., England.

Manufacturing plant: Comprehensive group facilities.

Research facilities: Comprehensive group facilities.

R&D specialties: Aircraft design, research and development.

Major product developments: Canberra bomber, trainer, interdictor and photo recon aircraft. Lightning, supersonic fighter aircraft (formerly Plb).

For technical inquiries: Chief Engineer's Office.

The Fairey Aviation Co. Ltd., North Hyde Road, Hayes, Middlesex, England.

Major product developments: Rotodyne VTOL; Gannet AEW Mk.3; anti-tank guided weapon; hydraulics; aluminum and steel fabrications; electronic instruments.

Foreign licensees: Kaman Aircraft Corp., Bloomfield, Conn., USA (Rotodyne).

Recent and/or current military contracts: Gannet AEW MK.3 for Royal Navy; Gannet AS Mk.4 for W. Germany; anit-tank guided weapon for British Army; Fireflash air-to-air guided weapon for RAF.

For technical inquiries: R. L. Lickley, Technical Dir. & Chief Engineer.

Fiat S.p.A., Fiat—Divisione Aviazione, Corso G. Agnelli 200, Torino, Italy.

Manufacturing plant: Aircraft section —Torino, Aero-Engines—Torino.

Research facilities: Caselle Works; Sangone Works.

R&D specialties: Military fighters; reconnaissance and training aircraft; small gas turbines.

Major product developments: Fiat G 91 lightweight fighter and its versions. Fiat 4700 "free turbine" air generator; Fiat 4032 axial flow turbojet; Fiat 4002 centrifugal flow small turbojet.

Future engineering research and development plans: Supersonic lightweight fighter aircraft and VTOL aircraft.

Foreign licensees: Dornier, Messerschmitt and Heinkel, in Germany, have Fiat G 91 and its versions.

Recent and/or current military contracts: G 91, NATO and Italian armed forces; F-86K, NATO; F-86E,F,D (overhaul), USAF.

For technical inquiries: Dr. Ing. Giuseppe Gabrielli.

Flight Refueling Ltd., Tarrant Rushton Airfield, Nr. Blandford, Dorset., England.

Manufacturing plant: Manufacturing

more on page 190

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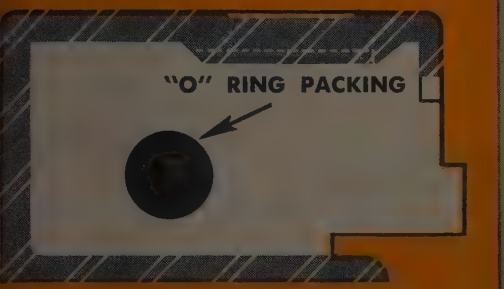
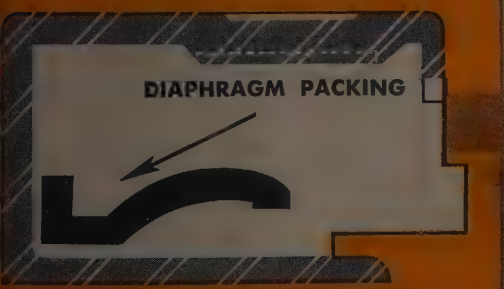
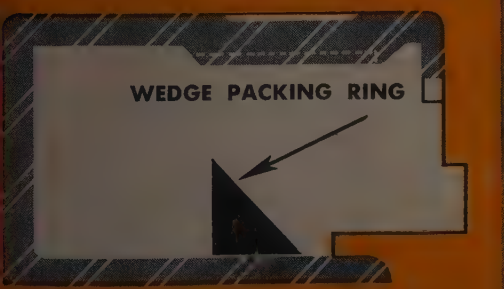
GITS HH-TYPE SEAL SERIES







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and testing of fuel system equipment for hydrocarbon, high test peroxide and liquid components. Manufacture of hose drum units from 50-600 Imp. gal per min, used for in-flight refueling.

Research facilities: Tarrant Rushton Airfield.

Engineering dept.: approx. 150 personnel.

Employment, total: approx. 900 personnel.

R&D specialties: Specialized fuel system equipment; testing of complete fuel systems; flight testing of in-flight refuelling system (probe and drogue); drone target aircraft.

Major product developments: Fuel systems equipment; in-flight refuelling equipment; all types of couplings.

Future engineering research and development plans: Smaller, lighter and more automatic refuelling in-flight units; more effective, longer range drone aircraft; fuel systems equipment for higher temperatures.

Foreign licensees: La Societe Carburateur Zenith, France; associated companies: Flight Refueling Inc., USA; Flight Refuelling (Canada) Ltd.

Recent and/or current military contracts: Direct contractors to USA, British, French, Belgian, Swedish, Swiss, Indian, Australian and Danish governments.

For technical inquiries: Sales Manager.

Folland Aircraft Ltd., Hamble, Southampton, England.

Manufacturing plant: 332,500 sq ft (including dispersals) floor space.

Research facilities: Hamble Works, 2,500 sq ft (approx.)

Engineering dept.: 1,000 personnel.

Employment, total: 2,800 personnel.

R&D specialties: High performance lightweight aircraft, lightweight ejection seats.

Major product developments: Gnat Mk. 1 and developments; Gnat Trainer; Types 1 and 4 ejection seats.

Future engineering research and development plans: Development and application of Gnat light fighter design philosophy, development of Folland Ejection Seat.

Foreign Licensees: Hindustan Aircraft (Private) Ltd., India; Valment Oy, Finland.

Recent and/or current military contracts: Ministry of Supply, 5 Gnat F Mk.1s; India, 40 Gnat F Mk.1s; Finland, 12 Gnat F Mk. 1s; Yugoslavia, 2 Gnat F Mk.1s; Ministry of Supply, 14 Gnat Trainers (pre-production development batch).

For technical inquiries: D. B. Smith, Asst. Chief Engineer.

Handley Page Ltd., Claremont Rd., Cricklewood, London, N.W. 2, England.

Manufacturing plant: Factories at Cricklewood, Radlett and Reading.

Research facilities: Turbojet wind tunnel for tests up to sonic speeds. Fully equipped structural test house.

Major product developments: Victor crescent winged 4-jet bomber; Dart Herald medium range branchliner.

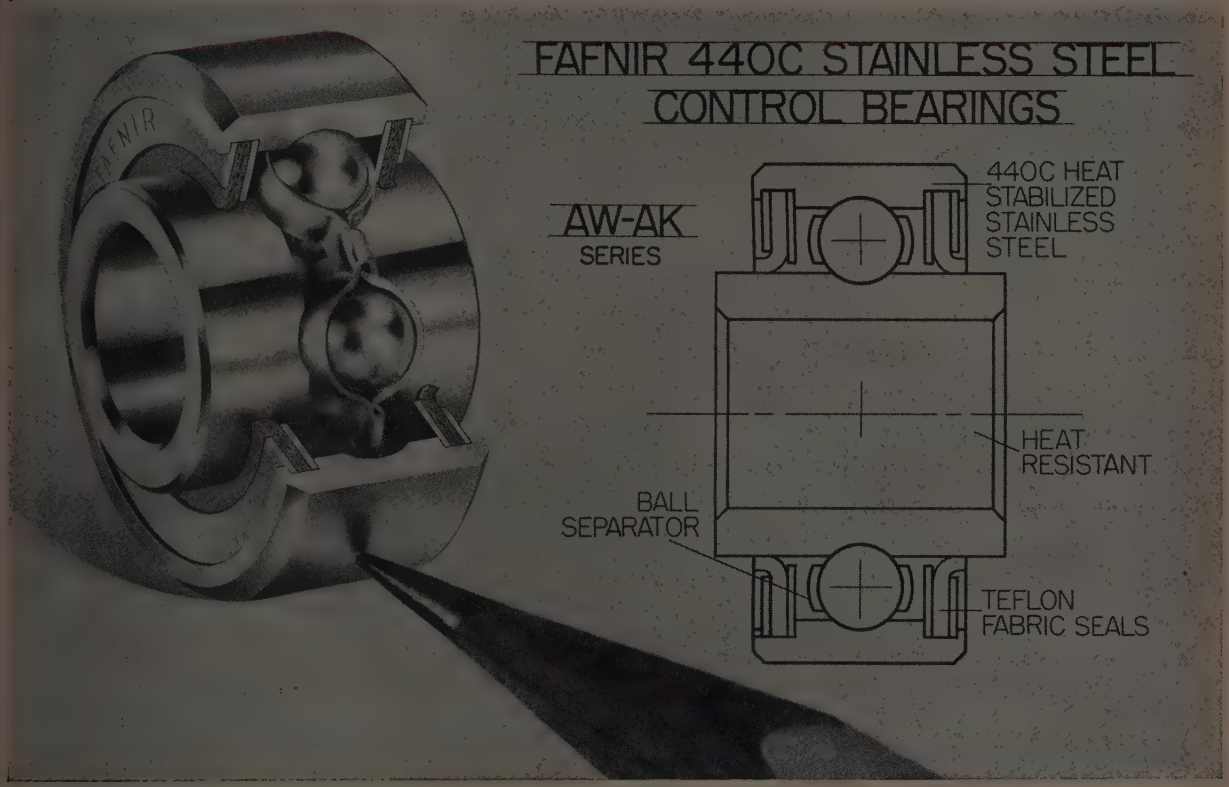
Future engineering research and development plans: H.P. 111; H.P. 113 12-seat jet transport.

Foreign licensees: None.

Recent and/or current military con-

more on page 192

NEW FOR HIGH-SPEED AIRCRAFT



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To meet the need for ball bearings designed specifically for high-speed aircraft "sensitive" control applications, Fafnir announces a new, high-temperature, low-torque series fabricated entirely of stainless steel.

Designated the AW-AK Series, these new, medium capacity ball bearings are heat-stabilized, and lubricated with heat-resistant oil. Teflon fabric seals, capable of withstanding temperatures in the 550° range, are available. These seals keep seal drag to a minimum.

The bearings are equipped with stainless steel ball separators that insure extremely low torque. Bearing widths to close tolerances permit ready mounting in standard brackets. This series is especially suitable for application in the critical area forward of the power boost system, where low torque, minimum play, and high temperature operation are required.

Send for new engineering data sheet. Write The Fafnir Bearing Company, New Britain, Connecticut.

AW-AK SERIES DIMENSIONS AND LOAD RATINGS

[illegible] NUMBER	B	D	W	H	A	E	C				
	BORE	[illegible] DIAMETER	WIDTH INNER [illegible]	WIDTH OUTER RING	SHOULDER DIAMETER INNER [illegible] (APPROX.)	CORNER CHAMFER x 45° INNER RING BORE +.015 −.000	CORNER CHAMFER x 45° OUTER RING O.D. +.015 −.000	BALLS NO.	BALLS SIZE	RADIAL LIMIT LOAD RATING LBS.	WEIGHT POUNDS (APPROX.)
	+.0000 −.0005	+.0000 −.0005	+.0000 −.0025	+.000 −.005							
AW3AK	.1900	.6250	.406	.312	.317	.005	.016	6	1/8	750	.018
[illegible]	.2500	.7500	.438	.312	.415	.005	.016	7	1/8	880	.028
[illegible]	.3125	.8125	.469	.344	.462	.015	.016	7	3/32	1370	.033
*AW6AK	.3750	.8750	.469	.344	.520	.015	.016	7	3/32	1370	.034
*AW8AK	.5000	1.1250	.562	.438	.681	.015	.016	8	3/16	2250	.075
*AW10AK	.6250	1.3750	.594	.469	.848	.015	.032	8	3/32	3060	.119
*AW12AK	.7500	1.6250	.656	.531	1.052	.015	.032	8	1/4	4000	.189
*AW16AK	1.0000	2.0000	.688	.562	1.334	.015	.032	10	1/4	5000	.296
*AW20AK	1.2500	2.2500	.688	.562	1.615	.015	.032	12	1/4	6000	.355

* Not in production. Will be produced as requirements justify tooling.

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R&D FACILITIES . . .

tracts: Production of Victor B.1 and B.2 for RAF.
For technical inquiries: R. S. Stafford.

M.L. Aviation Co. Ltd., White Waltham Aerodrome, nr. Maidenhead, Berks., England.
R&D specialties: Design, development and production of specialized aircraft, aircraft accessories, electrical equipment, guided missile ground handling equipment, airconditioning equipment.
Major product development: Same as above.
Future engineering research and development plans: Specialized aircraft, accessories, electrical equipment, ESE, air conditioning equipment.
Foreign licensees: None.
Recent and/or current military contracts: As in above.
For technical inquiries: The Chief Designer.

McMichael Radio Ltd., Wexham Rd., Slough, Bucks., England.
Manufacturing plant: Slough, 90,000 sq ft.
Research facilities: Slough, 20,000 sq ft.
Engineering dept.: 130 personnel.
Employment, total: 550 personnel.
R&D specialties: UHF transmitters and receivers; telemetry systems.
Major product developments: Printed wiring; guidance systems; antennas; relays; radar display systems; navigational and operational trainers.
Future engineering research and development plans: Guidance systems; submarine targets; evaluation and locating systems; automatic production control equipment.
For technical inquiries: R. Cave, Chief Development Engineer.

Messier S.A., 6, Avenue Raymond Poincare, Paris, France.
Manufacturing plant: Montrouge (Seine), 193,750.2 sq ft; Bidos (Basses Pyrenees), 96,875.1 sq ft; Ijeste (Basses Pyrenees), 32,291.7 sq ft; Arudy (Basses Pyrenees), 10,763.9 sq ft and 32,291.7 sq ft (light metals foundry).
Research facilities: Montrouge—static, dynamic testing; testing benches for hydraulic wheel brakes; electronics Arudy foundry—metallurgy, chemistry, X-rays, spectographs, etc.
R&D specialties: Landing gears—wheels, brakes, anti-skid devices; hydraulic devices, servomechanisms; auxiliary powerplants and valves for guided missiles; high pressure pumps.
Major product developments: Equipments for Dassoult 315, Mystere IV, SMB2, Mirage III, Etendard IV, Mirage IV, MD 415; Fouga CM 170; Nord 2501; Breguet 755; S 115-117-118; Alouette 'copter, Griffon, etc.
Future engineering research and development plans: hydraulic equipment for guided missiles; atomic energy valves and remote control equipments.
Foreign licensees: British Messier (agreement cancelled 1959); Technania, W. Germany; Italy.
For technical inquiries: W. Breguet, Ing. en Chef.

F.G. Miles Ltd., Shoreham Airport, Shoreham-by-Sea, Sussex, England.

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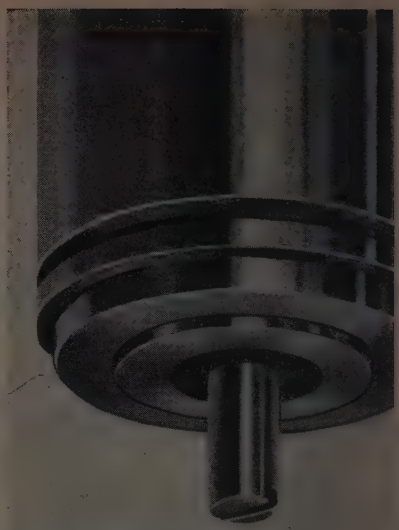

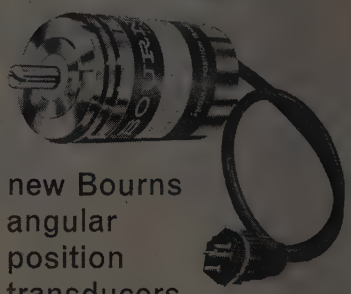

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New position transducer line designed for high accuracy servo-systems requiring infinite resolution—high sensitivity.
Differential transformer output signal for AC circuits. Available with integral demodulator for DC circuits.

Model	2200 (with Integral Demodulator)
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Input Voltage	26 v, 400 cps
Output Voltage	0.15 v per degree arc into 10K load
Linearity (20-0-20°)	±0.5%
Operating Temperature	—65° to +250°F
Frame Size	No. 15

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COMPLETE DUCTING SYSTEMS—designed to withstand rugged environmental extremes—are being created at Solar. Behind every Solar ducting component is more than thirty years of experience in producing top-quality aircraft components requiring advanced materials and imaginative fabricating techniques. Result: Solar today offers complete ducting and boundary layer control systems—designed to customer specifications—that are far ahead in the field. Materials used include Inconel X, A-286, 17-7PH, L-605 and others.

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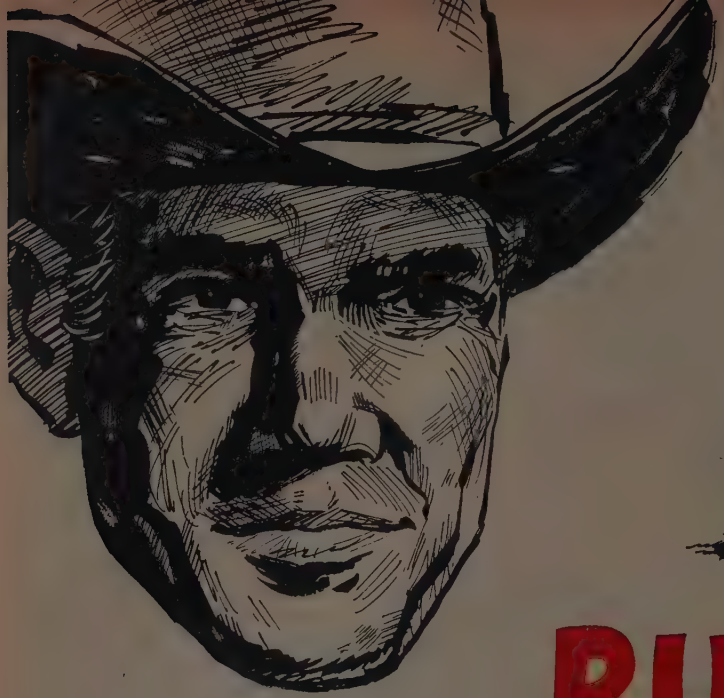

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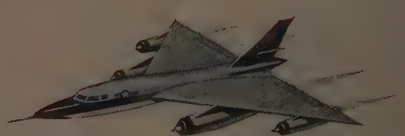

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Manufacturing plant: Shoreham, 95,000 sq ft. Hove, 15,000 sq ft; Lancing, 20,000 sq ft.
Research facilities: About 80% of above areas as required.
Engineering dept.: 100 personnel.
Employment, total: 400 personnel.
R&D specialties: Aircraft, electronics, plastics, nuclear engineering, high voltage equipment; high vacuum equipment.
Major product developments: Aircraft, aircraft components, electronic simulators, specialist equipment, reinforced plastics, corrosion-resisting equipment.
Future engineering research and development plans: Expansion of present facilities.
Foreign licensees: None.
Recent and/or current military contracts: Flight simulators for Sea Vixen, N.A. 39; simulator for flight refueling of V-bombers; plastic boost fins for Bloodhound; installation of vertical engine in Meteor.
For technical inquiries: Maj. General J. C. Haydon.

Murphy Radio Ltd., Electronics Division, Broadwater Road, Welwyn Garden City, Herts., England.
Manufacturing plant: Welwyn Garden City, 50,000 sq ft.
Research facilities: Welwyn Garden City, 20,000 sq ft.
Engineering dept.: 150 personnel.
Employment, total: 900 personnel.
R&D specialties: Aircraft secondary radar (DME); land-mobile and point-to-point communication.
Major product developments: "Rebecca", "Eureka", "Babs" system.
Future engineering research and development plans: All forms of communications equipment, computers and allied units.
Foreign licensees: Swedish Philips, Sweden; Van Der Heem, Holland.
Recent and/or current military contracts: Rebecca—Eureka—Babs; A.41 (equivalent PRC 10 etc.); B.40/41 naval communications; Leader Cable Receivers (Automatic landing system).
For technical inquiries: J. N. Boston, Asst. Sales Manager.

D. Napier & Son Ltd., Acton, London, W.3, England.
Manufacturing plant: Netherton (Liverpool) Aero-Engine production, and Acton—1,700,000 sq ft total.
Research facilities: At London, Luton and Liverpool: all forms of aerodynamic, mechanical, materials, chemical research.
Engineering dept.: 515 personnel.
Employment, total: 10,000 personnel.
R&D specialties: Gas turbine, rocket, ramjet, atomic energy, metallurgy, precision casting, piston engine.
Major product developments: Eland turboprop engine; Gazelle free turbine; Scorpion (single, treble and two double rocket engines; "Spraymat" de-icing systems; "Napiercast" precision investment casting (four processes, many materials).
Foreign licensees: Bronzavia (Paris), Spraymat; PacAero (Calif.), Spraymat.
Recent and/or current military contracts: Gazelle for Westland Wessex (Navy) Gazelle for Bristol 192 (RAF).
For technical inquiries: Sir Archibald

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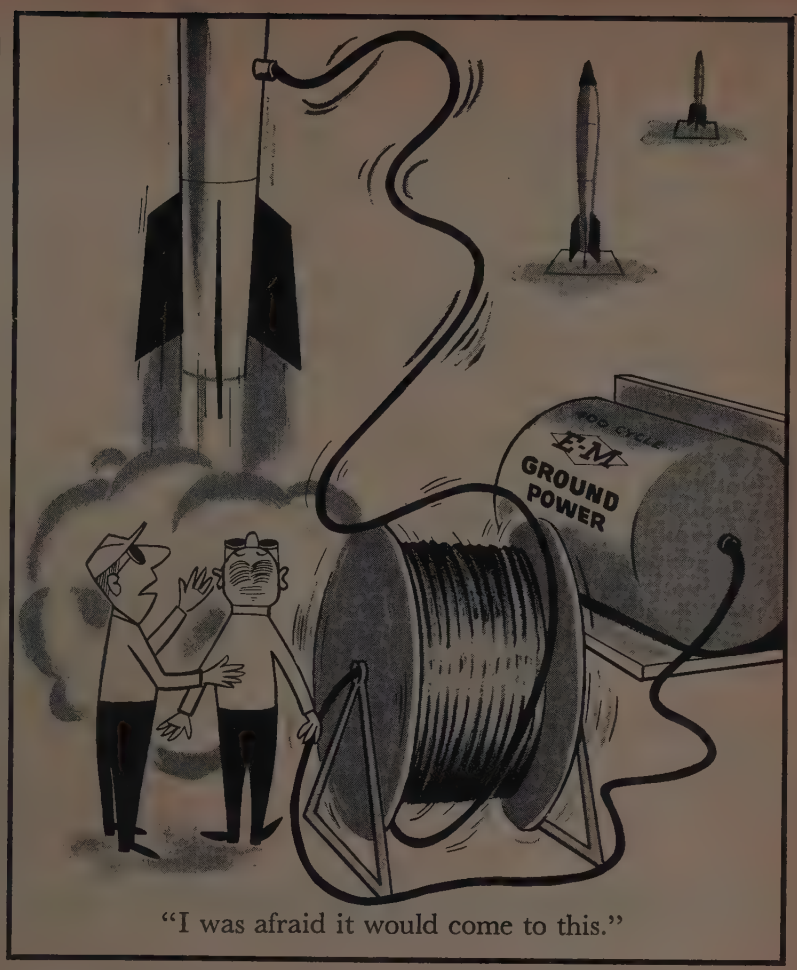

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Minneapolis 13, Minnesota

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Hope (Aero), Sales Dir. R. M. Hilary, Commercial Manager.

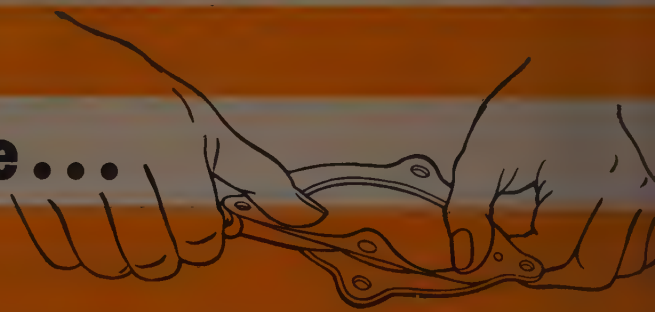
Negretti & Zambra Ltd., 122 Regent St., London, W.1, England.
Manufacturing Plant: Aylesbury, Bucks.; London, N. 1
R&D specialties: Fuel flow meters; aeronautical, meteorological instruments.
Major product developments: Fuel flow meters for Comet 4; temperature and pressure sensitive switches; fuel flowmeters with integrator; pressure switches; test bed thermometers; meteorological instruments.
For technical inquiries: Peter C. Webb.

Marconi's Wireless Telegraph Co. Ltd., Marconi House, Chelmsford, Essex, England.
Manufacturing plant: Chelmsford Works, 478,000 sq ft; Basildon (Essex) Works, 144,000 sq ft.
Research facilities: Great Baddow, Essex, 147,000 sq ft.
R&D specialties: Doppler navigator; transistorized airborne teleprinter receiver; high power 50 cm radar (500 kw); low power 50 cm radar (50 kw); fire control radar; air traffic data handling system; long range 10 cm radar height-finder; scatter communication.
Major product developments: Doppler navigator; transistorized airborne teleprinter receiver, etc. (as above).
For technical inquiries: Manager, Aeronautical Division; Manager, Radar Division.

Nord-Aviation, 2-18 Chatillon-sous-Bagneux (Seine) France.
Manufacturing plant: Chatillon-sous-Bagneux, Bourges, Les Mureaux, Meaulte —2,378,822 sq ft floor space.
Engineering dept.: 600 personnel.
Employment, total: 8,100 personnel.
R&D specialties: Air cargo transports; ramjets; guided missiles; ground-to-ground and air-to-air target drones.
Major product development: Noratlas; SS.10 and SS.11 anti-tank missiles; AA 5103 air-to-air missile; CT 10 and CT 20 target drones.
Recent and/or current military contracts: With U.S.A., Sweden, Germany, Britain, Israel.
For technical inquiries: Noël Daum, Technical Director.

Normalair Ltd., West Hendford, Yeovil, England.
Manufacturing plant: Yeovil Works, 90,000 sq ft floor space. Available for expansion, 45,000 sq ft floor space.
Research facilities: Yeovil, 16,200 sq ft.
Engineering dept.: 260 personnel.
Employment, total: 1,100 personnel.
R&D specialties: New design concepts for aircraft air conditioning; oxygen and high altitude survival equipment.
Major product developments: Air conditioning and pressurization systems and components for aircraft and missiles; aircraft oxygen equipment; lightweight breathing apparatus for medical, industrial and sporting uses; air conditioning equipment for large vehicles and ground support; accessories for nuclear power installations.
Future engineering research and development plans: Ultrasonic aircraft conditioning and pressurization systems; liquid oxygen systems; missile cooling and ancillary systems.
Foreign licensees: Service technique Militaire, Switzerland; Normalair (Canada) Ltd.; Normalair (Australia) Proprietary Ltd.

Our Superiority Here . . .



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Recent and/or current military contracts: Complete pressurization, air conditioning and oxygen systems of Blackburn NA.39; air conditioning of Dassault Mirage III; demand oxygen regulators for all British aircraft cooling for Avro weapon; complete pressurization, air conditioning and oxygen systems for NATO F-84F.

For technical inquiries: L. H. Hayward.

Palmer Aero Products Ltd., Penfold St., Edgeware Rd., London, N.W. 8, England.

Manufacturing plant: Penfold St., 200,000 sq ft. West Molesey, Surrey, 50,000 sq ft. Leyland, Lancs. (De-Icer Shop), 20,000 sq ft.

Research facilities: Penfold St. Development Labs.: 1,000 sq ft.

Engineering dept.: 60 personnel.

Employment, total: 600 personnel.

R&D specialties: Hydraulic equipment; aircraft wheels, brakes and associated equipment.

Major product developments: PTFE flexible hoses; precision filters; escape slides.

Recent and/or current military contracts: Participation in various main aircraft construction contracts from Ministry of Supply, including direct supply of pipes, valves, wheels, brakes, etc., for British military aircraft. De Havilland—PTFE (Fluoroflex) pipes for BEA Comet 4Bs.

For technical inquiries: Charles W. Lane, M.S.L.A.E.

Piaggio & Co., S. p. A., Via Antonio Cecchi 6, Genova (434), Italy (Main Office).

Manufacturing plant: Plant #1, Genova Sestri, 322,920 sq ft (covered); Plant #2, Finale Ligure, 441,320 sq ft (covered); Plant #3, Pontedera, 1,076,400 sq ft (covered); Plant #4, Pisa, 158,230 sq ft (covered).

Research facilities: (Aviation) Wind tunnel and hydrodynamic tank.

Engineering dept.: 1,000 personnel.

Employment, total: 6,500 personnel.

R&D specialties: Water-based and amphibian aircraft; low speed and STOL aircraft.

Major product developments: P.136-L trainer and executive amphibian; P.149 trainer, liaison and executive landplane; P.166 executive landplane; constant speed propellers for power range of 150-400 hp; piston engines (Lycoming license).

Future engineering research and development plans: P.155 2- and 3-engine turboprop amphibian for ASW, air-sea rescue, and transport; STOL aircraft.

Foreign licensees: Focke-Wulf, Germany (P.149); Trecker Aircraft Corp., U.S.A. (P.136).

Recent and/or current military contracts: P.136L trainer (Italian AF); P.149 trainer-liaison (German AF).

For technical inquiries: Dr. B. Canevali.

A. V. Roe & Co. Ltd., Greengate, Middleton, Manchester, England.

Manufacturing plant: Head office and Works, Manchester Works and Airfield, Woodford, Cheshire Design, research and manufacturing, England, Australia.

Research facilities: Manchester and Woodford Works, and London area.

Employment, total: about 8,000 personnel.

R&D specialties: All aspects of aircraft and guided weapons, including kinetic heating problems and flight research.

more on next page

. Guarantees Superiority Here . . .

Actually, our famous Shims of LAMINUM are perfect precision STAMPINGS. Consequently, we have perfected our own special equipment and tooling, our own skills and techniques, unknown to ordinary stampings producers. Result: the unique ability to quickly produce precision STAMPINGS...in any contour, in any size...in any quantity "one to a million"...at the lowest possible unit cost. We have 3 exclusive Methods—pick the one that fits *you* best...

1. FOR A FEW PIECES

Experimental or Pilot Stage

—we use our MACHINE CUT METHOD. No dies needed. Our special equipment, plus our unique techniques, are applied to produce small quantities at very low cost.

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—we use our *low-cost,* SHORT RUN METHOD. Our low cost tooling and simple dies, plus special presses, go to work to produce something more than "just a few." Quality is high—costs stay low.

3. FOR PRODUCTION RUNS

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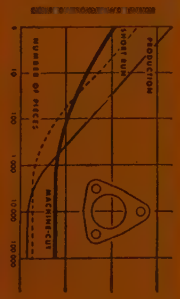

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He is looking at the conquest of space

The man above is studying the vibration reaction of a Union 6 PDT miniature relay, at the reliability laboratory of Convair-Astronautics, San Diego, Calif.

Result: These Union Switch & Signal relays were chosen by Convair for the guidance of their Atlas missile, launched into orbit December 18, 1958.

Extreme reliability was needed in the Atlas guidance system, to insure precise control of flight. And the Union relay subjected to thorough testing, answered that need.

Part of the 6 PDT relay reliability can be laid to its small size and its clean, simple, rotary design which gives it fewer inherent problems than other relays. In tests at Union Switch & Signal, it has proved its ability to give outstanding performance in critical dry-circuit control applications—was absolutely solid to 2,000 C.P.S. at 15 G!

The relay used in the Atlas is just one of a complete line of *dependable* relays designed by Union Switch & Signal. Write today for complete technical details.

"Pioneers in Push-Button Science"

UNION SWITCH & SIGNAL
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY
PITTSBURGH 18, PENNSYLVANIA

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Major product developments: Design, development and production of civil and military aircraft and guided weapons; analog computers; digital differential analyzers; metal honeycomb application; high temperature strain gages.

Foreign licensees: None.

Recent and/or current military contracts: Avro Shackleton M.R. 3 (maritime reconnaissance aircraft); Avro Vulcan B.1. (jet medium bomber); Avro Vulcan B.2 (jet medium bomber); Avro stand-off bomb, (powered guided air-to-ground missile).

For technical inquiries: E. Galitzine, Sales Manager.

Rolls-Royce Ltd., P.O. Box 31, Derby, England.

Manufacturing plant: Derby, Glasgow Crewe, Shrewsbury.

Research facilities: Derby, Barnoldswick, Hucknall.

Engineering dept.: 8,500 personnel.

Employment, total: 34,000 (Aero Div.); 42,000 including car works.

R&D specialties: Gas turbine aero engines, civil and military; rocket engines; nuclear propulsion.

Major product developments: Gas turbine aero engines.

Future engineering research and development plans: Continued research in gas turbine, rocket and nuclear propulsion fields.

Foreign licensees: Commonwealth Aircraft Corp., Australia; Fabrique National, Belgium; Hispano Suiza, France; Svenska Flygmotor, Sweden; Westinghouse Electric Corp., and Pratt & Whitney Aircraft Corp., U.S.A.

For technical inquiries: D. P. Huddie, General Manager, Sales & Service.

Royal Netherlands Aircraft Factories Fokker, Schiphol-Zuid, Amsterdam, Holland.

Manufacturing plant: Schiphol Works, 807,000 sq ft floor space (approx.) Dordrecht Works, 190,550 sq ft floor space (approx) Avio-Diepen/Ypenburg, 180,000 sq ft floor space (approx.)

Research facilities: National Aeronautical Research Institute (N.L.L.), Amsterdam; 3 wind tunnels (1 Mach 1, 1 Mach 1.3, and 1 Mach 5).

Employment, total: about 4,900 personnel.

R&D specialties: Civil and military transport aircraft.

Major product developments: Fokker F.27 Friendship turboprop airliner; F.27 de Luxe; F.27 Freightship.

Future engineering research and development plans: Civil and military transport aircraft.

Foreign licensees: Fairchild Engine & Airplane Corp., U.S.A.; Fokker Industria Aeronautica S.A., Rio de Janeiro, Brazil.

Recent and/or current military contracts: F.27 Freightship; Hawker Hunter; repair and overhaul of military aircraft.

For technical inquiries: H. C. van Meerten, Dty. Technical Director.

W. H. Sanders (Electronics) Ltd., Gunnels Wood Road, Stevenage, Herts.

Manufacturing plant: Gunnels Wood Road, Stevenage.

Research Facilities: Gunnels Wood Road, Stevenage, Argyle Way, Stevenage.

Employment, total: 320 personnel.

more on page 200

DOW | MAGNESIUM PRODUCTS

1. SATELLITE
The rigid external skin of the weather satellite is made of magnesium alloy, AZ31B. It is plated with gold and other materials to reflect heat.

2. SECOND-STAGE UNIT
The skin is made of HK31A, magnesium-thorium alloy sheet. This elevated temperature alloy must withstand temperatures of 700° F. and above.

3. SPACER SECTION
The skin is formed of AZ31B magnesium alloy sheet. Magnesium was selected for its light weight and high strength-to-weight ratio.

4. TAILCAN
Again AZ31B magnesium alloy was chosen because it is the world's lightest structural metal.

LIGHTWEIGHT MAGNESIUM SPEEDS WEATHER ROCKET FOUR WAYS

The shell of the satellite and several parts of the Vanguard Rocket are made of standard magnesium-aluminum-zinc and magnesium-thorium alloys. Why was magnesium chosen for this project? Because it is the lightest commercially available metal that could be easily fabricated—one with a high strength-to-weight ratio and able to withstand elevated temperatures encountered during flight. Magnesium alloys met these demanding requirements, as proved by tests conducted by the Naval Research Laboratory in Washington, D. C.

Write today for new illustrated brochure on aircraft, missiles and rockets. Contact the nearest Dow Sales Office or write to THE DOW CHEMICAL COMPANY, Magnesium Products Sales Dept., Midland, Mich., Dept. MA1302EW6.

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

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R&D specialties: Waveguide test equipment and components; flexible waveguide assemblies, for frequency bands 2000-22,000 mc/s; magnetic amplifier assemblies; custom built control systems.

Major product developments: Waveguide test equipment; flexible waveguide assemblies, for frequency bands 2000-22,000 mc/s; encapsulated E type and toroidally wound transducers; magnetic amplifier control systems, automatic control equipment for resistance welding; airborne waveguide runs; radar and missile subassemblies.

Future engineering research and development plans: Complete automatic control systems using both magnetic amplifier and power transistor circuitry; flexible waveguide and waveguide test equipment and components in the 8 and 4 mm bands; transistorized electronic test equipment.

Foreign licensees: None.

Recent and/or current military contracts: Military contract for the Ministry of Supply, Admiralty, and the Royal Aircraft Establishment.

For technical inquiries: R. G. Roberts,

Our most potent weapon in the battle of time:
QRC*
In advanced military electronics research, the ability to do the job *isn't good enough*. The job must be done *reliably* and *on time*.
Hallicrafters' QRC program was originated to provide not only the finest of engineering facilities and people, but the flexibility required for immediate, crash effort on critical electronics problems.
Hallicrafters has provided our military forces for the past six years with a Quick Reaction Capability that has played a major role in helping to win the battle against time.
* Quick Reaction Capability: Refer to Air Force Reg. No. 80-32
The tough jobs get off the ground in a hurry at . . .
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Chicago 24, Ill.
Qualified Engineers: new contracts have created openings. Contact William F. Frankart, Director of Engineering.
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Short Brothers & Harland Ltd., Queen's Island, Belfast, N. Ireland.

Manufacturing plant: Main factory, 1,000,000 sq ft, plus several subsidiary factories; Main Machine Shop, 50,000 sq ft.

Research facilities: Transonic wind tunnel; complete range of component fatigue testing machines; new 3-story research block staffed by specialist sections and systems group; several fully-equipped laboratories.

Employment, total: 8,000 + personnel.

R&D specialties: Research into automatic flight and autostabilizer systems; methods of guidance for guided weapons, aircraft and industrial hydraulics; analog computers and associated computing equipment.

Major product developments: Unmanned target aircraft; SC.1 VTOL research aircraft; SEACAT ship-to-air missile; Britannia 253 (military version); production of Britannic long range cargo aircraft for RAF Transport Command.

Future engineering research and development plans: Continuing development of all research as given above: application of VTOL to military and civil projects.

Foreign licensees: None.

Recent and/or current military contracts: (1) Development of SEACAT missile to replace Royal Navy's 40 mm guns; (2) general research with Short General Purpose Vehicle (GPV); (3) Production of Britannic for RAF; (4) production of Canberra U Mark 10 target aircraft for guided weapons trials (remote radio control system perfected and installed by Shorts); (5) Canberra PR.9 reconnaissance aircraft for RAF.

For technical inquiries: Chief Engineer.

Smiths Aviation Division, Kelvin & Hughes Ltd., Cricklewood, London, N.W. 2, England.

Manufacturing plant: Cheltenham, Basingstoke, London, Glasgow.

Research facilities: Full research and development facilities at each factory.

Employment, total: 20,000 personnel (in all Smiths companies).

R&D specialties: Autopilots; flight systems and full aircraft instrumentation.

Major product developments: Smiths SEP. 2 autopilot; Smiths flight system; flight data system; rapid processing photographic projector; synchros; small motors and components.

For technical inquiries: J. Rivaz, Technical Sales Manager.

Societe d'Etude de la Propulsion par Reaction (SEPR), 1, Voie des Sables, Villejuif (Seine), France.

Manufacturing plant: Argenteuil.

Research facilities: Villejuif (basic Research and design center), 376,736 sq ft. Villaroche (liquid propellant rocket engine test center) Istres (B. du R.) solid propellant rocket engine test center).

Engineering dept.: 80 personnel.

Employment, total: 750 personnel.

R&D specialties: Rocket engines for fighter and interceptor aircraft, and for guided missiles.

Major product developments: SEPR 841 (for Mirage III); SEPR 631 (for Trident II); SEPR 703.

Foreign licensees: Bombrini; Parodi; Delfino, Italy.

more on page 202

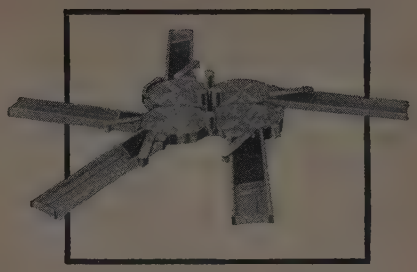
LARGE CAPACITY FILES / RAPID RANDOM ACCESS / EFFICIENT ROUTINE PROCESSING

A system with *complete* files, *complete* data and *complete* processing . . . to handle all operations.

It's a proven fact . . . that of the total work necessary to put a missile into the air, a staggering 90% is primarily logistical and involves the control of many individual maintenance parts. This figure becomes compounded as the number of inactive, but ready-to-fire missiles increases . . . and keeping track of their individual needs becomes a herculean task.

It is clear that an efficient system of organizing, filing and searching great masses of data at high speeds, and at realistic costs is necessary. *The Magnavox Company* answers the need for "discrete" unit data record handling for both government and industry with *Magnacard*.

You are invited to investigate and make use of these new techniques . . . write today for illustrated brochure.



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DATA HANDLING EQUIPMENT BY

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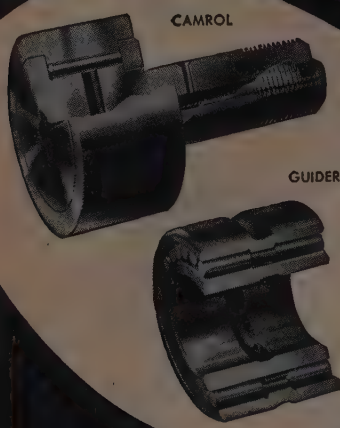
McGILL
CAMROL and GUIDEROL
bearings



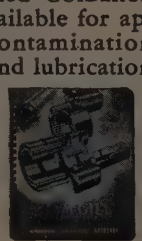
...add dependability to ground support equipment

High capacity in limited space plus precision accuracy make these bearings ideal for use as track, guide and support rollers in missile and rocket ground support equipment.

CF SERIES CAMROL bearings feature an integral stud and heavy duty outer race. They eliminate the cost of building up improvised bolt and roller units and withstand the shock of heavy loading. Also available with seals and pre-lubricated.

GR SERIES GUIDEROL bearings provide full complement roller capacity with self-guided rollers for true-running trouble-free performance. SG SERIES sealed GUIDEROL bearings are also available for applications where contamination must be sealed out and lubrication sealed in.

For data on the complete line of McGill Bearings, send for Catalog No. 52A



engineered electrical products
McGILL
precision needle roller bearings

McGILL MFG. CO., INC., Bearing Division
621 N. Lafayette St., Valparaiso, Indiana
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R&D FACILITIES . . .

Recent and/or current military contracts: Classified.
For technical inquiries: Documentation Service.

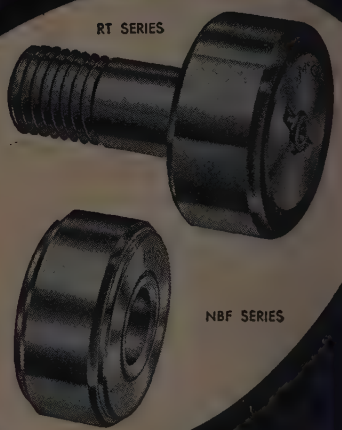
Sud-Aviation, 37, Boulevard Montmorency, Paris 16, France.
Manufacturing plant: Toulouse, 1,661,428.7 sq ft floor space; Marignane, 997,198.9 sq ft floor space; Courbevoie, 949,429.8 sq ft floor space; St. Nazaire, 740,427.2 sq ft floor space; Bouguenais, 831,780.4 sq ft floor space; La Courneuve, 528,327.6 sq ft floor space; Bordeaux (SFERMA), 427,523.8 sq ft floor space; Rochefort, 295,781.3 sq ft floor space; Cannes, 145,850.8 sq ft floor space.
Research facilities: Experimental wind tunnels in Suresnes (one supersonic), La Courneuve, Marignane; laboratories for materials research (sandwich, plastics, etc.); radiotechnics, stress and static tests, aerodynamics.
Employment, total: 21,058 (as of Nov. 1958).
R&D specialties: Civil transport; rotary wing aircraft; guided missiles.
Major product developments: SE Caravelle; SE 3200 tri-turbine 'copter (capacity 2028 seats); SE 3130 Alouette II turbine-powered 'copter; SE 116-117 ground support aircraft.
Future engineering research and development plans: SE Caravelle (based on engine development); turbine-powered 'copters.
Foreign licensees: Republic Aviation Corp., U.S.A. (Alouette II).
Recent and/or current military contracts: SE 3130 Alouette II; prototypes of SE 116-117 Voltigeur; prototypes of SE 3200.
For technical inquiries: Y. Montet-Jourdran, Public Relations Dept.

Svenska Aeroplan Aktiebolaget (Saab), Linköping, Sweden.
Manufacturing plant: 3,229,170 sq ft floor space.
Research facilities: Climate chamber (160,000 ft altitude and—70C): Mach 1.5 wind tunnel; fuel test installations; heat test installation, etc.
Engineering dept.: 1,500 personnel.
Employment, total: 8,000 personnel.
R&D specialties: Advanced weapon systems.
Major product developments: Saab 35A interceptor fighter; Saab 35B interceptor and attack aircraft; Saab all-weather fighter; Saab 91D Safir trainer.
Foreign licensees: Folland Aircraft, England (ejection seats); U.S. Government (bomb sight).
For technical inquiries: Address company only.
Recent and/ or current military contracts: Saab 35A; Saab 35B; Saab 32B; Saab 91D, Sweden.

Svenska Flygmotor AB, Trollhattan, Sweden.
Manufacturing plant: 710,417.4 sq ft floor area.
Research facilities: 118,402.9 sq ft Mach 3-6 wind tunnel (0.5x0.5 m). Free jet wind tunnel for ramjet testing, variable Mach number during tests (1.5—3.15). Test cells with various inlet pressures (to 7.5 at. and 175 kg/s air) and inlet temp. (—75C to +400C).

more on page 204

McGILL
Aircraft
needle bearings



...insure performance under aircraft specifications

Full complement needle bearing capacity, precision accuracy to NAS and AFBMA standards, non-separable construction, lightweight and high material selection standards qualify MCGILL RT, NBF, NBL and NBC bearings for aircraft cam, track, and guide roller applications. Surfaces plated as required.

RT and HRT SERIES— for use when a cantilever type stud mounting is required. Plating or surface treatment and lubrication holes supplied as application dictates.

NBF AND NBL SERIES — for use in applications where the bearing O. D. is unsupported and will support rolling loads in cam or track support.

NBC SERIES — for applications where bearing O. D. can be supported in a housing. Suitable for slow rotation and oscillation.

Consult our Engineering Department for Special Aircraft bearings built to specification —

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precision needle roller bearings

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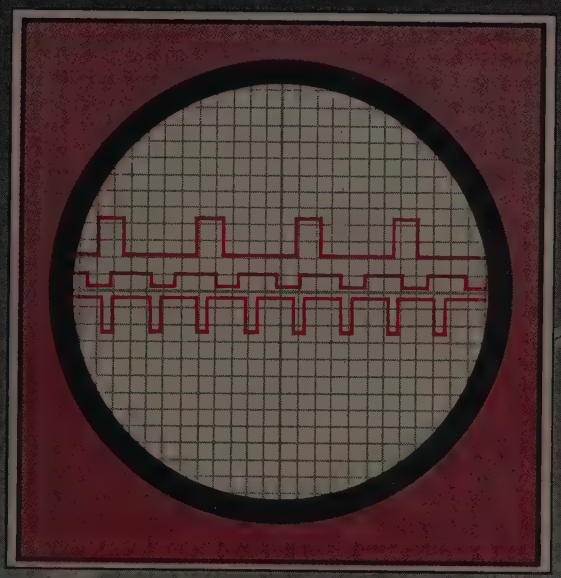
PRECISE PROGRAMMED TIMING



WESTERN DESIGN Timing Devices provide flexible, highspeed, multi-circuit programmed switching for critical applications such as automatic checkout, flight control, rocket firing, propulsion systems, and satellite programming.

WESTERN DESIGN has more than a decade of successful experience in the design and manufacture of timing devices, intervalometers, and programmers. This equipment — either rotary or solid state — with AC or DC drives (current and pulse length to specifications), can be engineered to your exact application.

TYPICAL WESTERN DESIGN TIMING DEVICES NOW IN USE:

MISSILE CHECKOUT TIMERS—The only 10-channel timing devices ever produced to meet military specifications. Contact bounce less than 60 microseconds.

ROCKET INTERVALOMETER—Firing device switches 15 ampere high speed pulses to multiple rocket and auxiliary control circuits. High vibration & life capabilities.

USI **Western Design**

DIVISION OF U. S. INDUSTRIES, INC.

WESTERN DESIGN OFFERS PROVED PERFORMANCE AND RELIABILITY in the engineering and production of complete instrumentation systems, support equipment, electro-mechanical and rotary devices, flyaway cargo hoists, training systems, simulators, teaching machines and materials, ASW systems and components, hydraulic fluid systems, landing gear, and heavy ground and shipboard handling equipment.

WD-24-59

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DYNAMICS ENGINEERS

Immediate openings for vibration, flutter, and dynamic analysis engineers to work on the most advanced weapon systems—such as the B-70, the F-108, and the X-15, first manned space ship.

A background in AE, ME, or other applicable experience is necessary. Qualified vibration engineers will calculate and measure vibration levels for consulting on procedures to insure crew comfort and work out vibration environment problems on equipment of particular airframes. The flutter and dynamic analysis engineers will evaluate flutter characteristics, including servo systems, of particular airframes by analytical techniques and by the use of dynamic models, and conduct other studies relating to gust penetration, landing, and taxi conditions.

For more information please write to: Mr. P. F. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF

NORTH AMERICAN AVIATION, INC.

Check Employment Form on Page 153

R&D FACILITIES . . .

Comprehensive test rig of 16,000 hp and 10,000 rpm.

Engineering dept.: 525 personnel.

Employment, total: 2,200 personnel.

R&D specialties: Jet engine afterburners, ramjets, rockets. Fuel system for afterburners, ramjets and rockets.

Major product developments: Avon jet engines under license from Rolls-Royce.

Future engineering research and development plans: Classified.

Foreign licensees: Stratos Div., Fairchild Engine & Airplane Corp., U.S.A. Solartron Electronic Group Ltd., Surrey, England.

For technical inquiries: Gustaf Gudmindson, Technical Director.

Teddington Aircraft Controls Ltd., Cefn Coed, Nr. Merthyr Tydfil, South Wales, U.K.

Manufacturing plant: Main Works, Merthyr Tydfil, 110,000 sq ft. Bellows Div., Ammanford, 24,000 sq ft.

Research facilities: Merthyr Tydfil, 32,000 sq ft.

Engineering dept.: 120 personnel.

Employment, total: 1,450 personnel.

R&D specialties: Automatic systems

more on page 206

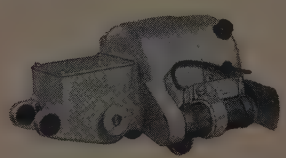
you get the **RIGHT MOTOR...**

for your power-driven product with

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Totally enclosed fan-cooled 27 volt DC motor for dry air pump drive. Frame 3¼ x 1⅝



Gearmotor with one spur gear and one worm gear stage giving right angle drive for business machines. Frame 3⅜ x 1⅜

⅙ Horsepower two-stage "by-pass" unit (motor separately ventilated) for light duty commercial vacuum cleaners.

Two-pole 60 cycle AC motor incorporating propeller fan and high speed blower driven through step-up gear train. Frame 4⅛ x 1¼

You get the *right* motor to assure the product performance desired . . .

You get the *right* motor to meet weight and space requirements . . .

You get the *right* motor cost-wise, too, because . . .

Lamb Electric motors are *engineered* to the application and *mass-produced* to obtain the most favorable cost.

May we demonstrate these advantages of our nearly half-century of experience in the small motor field?

NEW! 8-page Folder describes these and other Lamb motors. Send for your copy.

THE LAMB ELECTRIC COMPANY • Kent, Ohio

A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

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STEPS IN THE RACE TO OUTER SPACE

Cosmic Butterfly

Spreading its wings to absorb the eternal flow of solar energy is the Cosmic Butterfly, a space vehicle of a type first conceived by Dr. Ernst Stuhlinger of Redstone Arsenal.

Each of the fifty-foot parabolic mirrors in the wings concentrates the Sun's rays on a boiler at its focal point. Steam is developed, which drives a 200-kw turbo-generator in the base. Cooled by frigid outer space in heat diffusers, the steam reverts to water and is pumped back to the boiler to be used over and over again.

The current thus generated drives the main propulsion unit, an ion rocket in which powerful electric fields accelerate charged particles, shooting them from the rear of the rocket exactly as the electron gun in your TV set bombards the screen. Sunlight, then, is the power source, whereas cesium is the propellant.

While the recoil thrust is relatively small, the weightless vehicle is operating in a vacuum and the push is enough to enable the Butterfly to reach interplanetary speeds. Unlike conventional rockets, the Butterfly is under power the entire trip. Half way to its destination it turns around, and the ion thrust is used to slow the craft down to arrival speeds.

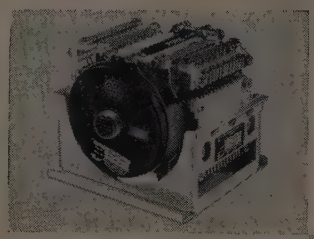
Since its thrust is entirely inadequate to cope with the gravity of major planets, the Cosmic Butterfly never lands. It is assembled in space and shuttles between artificial satellites.

The Cosmic Butterfly could carry ten passengers and 50 tons of cargo from an Earth satellite to a comparable one orbiting around Mars in about one year of continuous travel.

Inertial navigation systems will play an increasing role in the exploration of outer space. **ARMA** is actively supporting the Air Force's program in long range missiles and is in the vanguard of the race to outer space. **ARMA** . . . Garden City, New York. A Division of American Bosch Arma Corporation.

AMERICAN BOSCH ARMA CORPORATION

THREE NEW MINIATURES ADDED TO BENDIX GYRO TRANSMITTER FAMILY

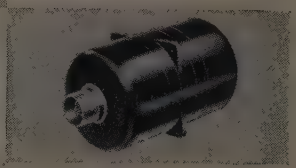


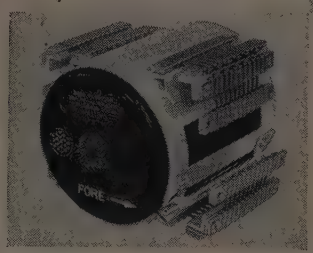
VERTICAL GYRO TRANSMITTERS

3¾" x 5" without mount
... ¼° vertical accuracy

FREE GYRO TRANSMITTERS

4" x 5" . . . drift less than ¼° per minute on either axis





DIRECTIONAL GYRO TRANSMITTERS

3¾" x 4½" without mount...6° drift per hour max.

SOME ADVANTAGES TO YOU

★ Integral mount with torsion cable suspension on Directional and Vertical Gyro Transmitters protects against shock and vibration.

★ Gyros are completely self-contained, requiring no erection amplifier.

★ Our mass production facilities make gyros available to you at volume prices and on fast delivery schedules.

★ If our standard units don't match your needs exactly, we will design special gyros that will—and still give you the benefit of mass production without sacrifice of quality.

Eclipse-Pioneer Division
Teterboro, N. J.
District Offices: Burbank and San Francisco, Calif.; Seattle, Wash.; Dayton, Ohio; and Washington, D. C. Export Sales & Service: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.

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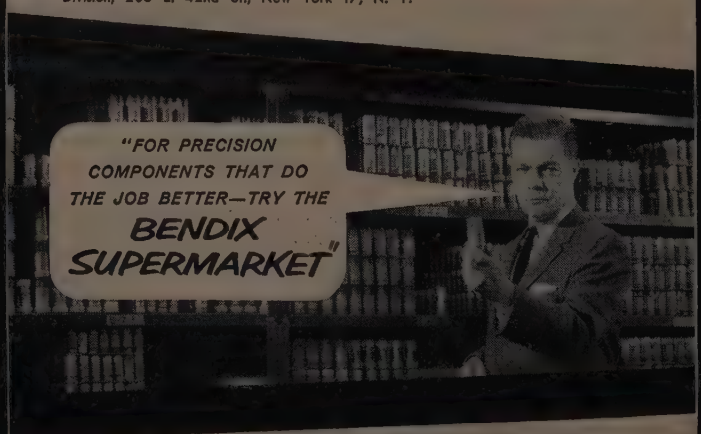

Write in No. 151 on Reader Service Card at start of Product Preview Section

for airborne or ground support use involving control of temperature, pressure or time.

Major product developments: Temperature and pressure controls; hot air and gas valves (electrically or pneumatically operated); time switches; accelerometers; pressure transducers; precision potentiometers; flexible metallic bellows in ferrous and nonferrous metals.

Future engineering research and development plans: Electronic control equipment for extreme ambient conditions.

Foreign licensees: Societe Anonyme A.B.G., France.

Recent and/or current military contracts: Classified.

For technical inquiries: J. E. Griffiths, Technical Liaison Manager.

Thermal Control Co. Ltd., Marine Works, Sackville Rd., Hove, Sussex, England.

Manufacturing plant: 50,000 sq ft.

Engineering dept.: 8 personnel.

Employment, total: 150 personnel.

R&D specialties: Pressure operated switches and aircraft fire detection system; toggle switches.

Future engineering research and development plans: Pressure transducers.

Foreign licensees: Souriau et Cie, Seine, France; Parmatic Engineering, Owen Sound, Ontario, Canada.

For technical inquiries: H. R. Benton.

The Tungum Co. Ltd., The White House, Arle, Cheltenham, Glos., England.

Manufacturing plant: Light machining; tube manipulation; assemblies; machine tool manufacture; Tungum alloy supply; forgings, castings, etc.

Research facilities: Research in anticorrosion, sea water and air; pressure testing.

Engineering dept.: 100 personnel.

Employment total: 130 personnel.

R&D specialties: Machine tool development.

Major product development: Multihead drilling machine; power hack saw; spark erosion electrodes (Tungum alloy).

Future engineering research and development plans: New machine developments.

Foreign licensees: None.

Recent and/or current military contracts: Hydraulic tubing supplies for Comet, Hunter, D.H. 110 aircraft and others anti-magnetic tools and equipment (Tungum alloy) used by Royal Navy; tubing, etc., supplied regularly to Ministry of Supply.

For technical inquiries: A. E. Barden, Sales Manager.

Turbomeca, Bordes (Basses-Pyrénées), France.

Manufacturing plant: Bordes, 5,735 sq ft floor area. Mezieres on Seine, 465 sq ft floor area.

Research facilities: More than 30 engine test beds.

Employment, total: about 1,500 personnel.

R&D specialties: Small gas turbines.

Major product developments: Marbore II turbojet; Artouste II shaft turbine; Palouste IV gas generator.

Future engineering research and development plans: Turboprop units, Bas-

tan, Astazou; shaft turbine, Turmo III B, and Artouste III B.

Foreign licensees: Jugoimport in Belgrad, Yugoslavia; Continental Aviation & Engineering Corp., Detroit, U.S.A.; Blackburn & General Aircraft Ltd., England; Empresa Nacional de Motores de Aviacion, Barcelona, Spain.

Recent and/or current military contracts: Marbore II; Artouste II; Palouste IV.

For technical inquiries: J. Szydlowski, President General Director.

Ultra Electric Ltd., Special Products Division, Western Avenue, Acton, London, W.3, England.

Manufacturing plant: Acton Works, 150,000 sq ft floor space; Gosport Works, 100,000 sq ft floor space; Chalk Farm Works, 60,000 sq ft floor space.

Research facilities: Acton, 30,000 sq ft.

Engineering dept.: 400 personnel.

Employment, total: 2,500 personnel.

R&D specialties: Aircraft controls and radio equipment; radio beacons; radar simulators; data control and computer equipment; transistorized power supply and test units; electric servo systems.

Major product developments: SARAH air/sea rescue radio beacon and variants; Sonobuoy submarine location transmitter; marine radar simulator; jet and turboprop engine controls; communication control systems.

Future engineering research and development plans: VHF & UHF communication systems for vehicle and railway control, missile control and countermeasure systems; aircraft crash position indicator.

Foreign licensees: Simmonds Aerocessories Inc., New York, U.S.A.

Recent and/or current military contracts: Sonobuoy, U.K. and Germany; jet pipe temperature controls; drone engine control equipment.

For technical inquiries: John Turrill, Technical Sales Manager.

Vickers-Armstrongs (Aircraft) Ltd., Vickers House, Broadway, London, S.W. 1, England.

Manufacturing plant: Weybridge Works, Surrey; South Marsdon, Wilts; Hurn, near Bournemouth.

Major product developments: Viscount turboprop airliner; Vanguard turboprop airliner; Valiant; Swift.

Future engineering research and development plans: Vickers V.C. 10 jet airliner; the TSR.2.

Recent and/or current military contracts: Vickers Valiant; Swift for RAF and Royal Navy.

For technical inquiries: The company only.

Western Manufacturing (Reading) Ltd., Aircraft Division, The Aerodrome, Woodley, Reading, Berks., England.

Manufacturing plant: Reading, 800,000 sq ft. Southampton, 100,000 sq ft. Reading aerodrome property, 230 acres.

Research facilities: Reading, 15,000 sq ft.

Engineering dept.: 75 personnel.

Employment, total: 1,200 personnel.

R&D specialties: Complete equipment for environmental testing of projects in all their aspects.

Major product developments: Automatic equipment, high temperature relays, electro-mechanical servo mechanisms and thermostatic devices.

Future engineering research and development plans: Depends to some extent on requirements of space/aeronautics industry.

Foreign licensees: Hydra-Power Corp., U.S.A. (electro-hydraulic equipment); Standard-Thomson Corp., U.S.A. (wax element thermostats); Electro-Film Inc., U.S.A. (solid film lubrication processing).

Recent and/or current military contracts: Ministry of Supply contracts for electro-mechanical control devices; from aircraft firms for design and development of specialized component equipment; from guided missile firms to design and develop special automatic/electronic inspection test rigs; NATO contract to supply hydraulic pneumatic control equipment for operational aircraft.

For technical inquiries: W. Davis, Sales Manager.

Westland Aircraft Ltd., Yeovil, Somerset, England.

Manufacturing plant: Full design and construction plant for all types of rotary wing aircraft; airfield.

Research facilities: Structural and mechanical test labs; rotor test tower; metallurgical and chemical labs.

R&D specialties: All aspects of 'copter engineering.

Major product developments: Whirlwind Mk. VII and Wessex 'copters.

Future engineering research and development plans: Design and development of turbine-powered 'copters.

Foreign licensees: None.

Recent and/or current military contracts: Whirlwind and Wessex helicopters in quantity production for Royal Navy, for which Westland is sole supplier of 'copters.

For technical inquiries: W. W. Hinks.

Wilmot Breeden Ltd., Flight Products Division, Amington Rd., Tyseley, Birmingham 25, England.

Manufacturing plant: Birmingham, 100,000 sq ft approx.

Research facilities: Birmingham and Bridgewater.

Engineering dept.: 100 personnel.

Employment, total: 600 personnel approx.

R&D specialties: Formation of metals in cold state.

Major product developments: Hollow blades; heat transfer units; cones; venturis; hollow vessels, including pistons.

Future engineering research and development plans: Finding industrial applications; increasing range in terms of physical size.

Foreign licensees: None.

Recent and/or current military contracts: Inlet guide vanes on Tyne, Sapphire, Conway, Gyron Jr.; 30 mm shells by pressed formation; 40 mm shells by cold extrusion.

PICTURE CREDITS: Cover, p. 6—S/A (Meyerriecks); p. 39—Sud Aviation; pp. 40-46—Fairey, Sud Aviation, Saab, SNECMA, Handley Page, Short Bros. & Harland, Nord, Power Jets, Saunders-Roe, de Havilland, Rolls-Royce, Napier, Fiat, Blackburn & General, Bristol-Siddeley; pp. 47-51—Marconi's, General Electric Ltd., Ferranti, Decca Navigator; pp. 56-59—Hiller Aircraft; pp. 79-86—Hofman Labs.; pp. 89-94—General Electric; pp. 101-107—Jamison Cold Storage Door; pp. 118-121—Servo Corp. of America, FAA.

P.S. and don't forget these other quality products at the

BENDIX "SUPERMARKET"

With our greater variety and greater volume of the precision components listed below, we have become the "supermarket" of the industry. We feature fast delivery and mass-production economy—plus the highest precision quality.

400-CYCLE SYNCHROS
(Frame sizes: 8, 10, 11, 15, 22)
Control Transformers • Differentials • Receivers • Resolvers • Transmitters

GYROS
Rate and Roll Gyro Transmitters • Stable Platforms

MOTORS AND GENERATORS
Gear Head Motors and Motor Generators • Low-Inertia Servo Motors • Motor Generators • Precision Induction Tachometer Generators • Rate Generators

PACKAGED COMPONENTS
Analog-Digital Converters • Azimuth Counters • Cam Compensators • Clutched Synchros • Dual-Speed Synchros • External Slip-Ring Synchros • Follow-Up Mechanisms • Miniature Differential Gear Assemblies • Servo Assemblies

RADAR DEVICES
Airborne Radar Antennae • Ground Antenna Pedestals

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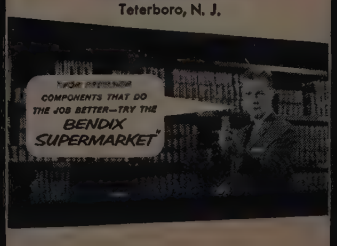

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ALL ICBM'S USE . . .

MOOG servoactuators . . .

. . . in their rocket gimballing systems

Moog servoactuators are compact, lightweight package units that typically include an actuating cylinder, servovalve, and feedback sensing device. These integrated units offer the advantages of a comprehensive custom design including reduced complexity and retaining high performance. Additional special features can be incorporated to meet particular applications.

In addition to ICBM and other missile, rocket, and aircraft applications, Moog servoactuators can function wherever rapid, accurate, high force positioning is essential in an electro-hydraulic system.

For complete details on Moog servoactuators write for Catalog 170.

MOOG VALVE CO. INC. PRONER AIRPORT, EAST AURORA, NEW YORK

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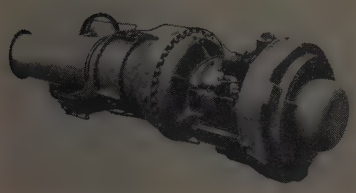
product preview

European
Aerospace Progress

TURBINE ENGINE
designed for helicopters



Reliability and low cost are the important design and development criteria that were applied to the creation of the A.129 Mk. 3 free turbine engine for rotary wing aircraft, says **Blackburn & General Aircraft, Ltd., Dept. S/A, Brough, Yorkshire, England.** The design maximum power rating is 970 shp at sea level under ISA conditions; a reduction gear box can limit the power to 700 shp, maximum, for single-engine aircraft.

The compressor is a three-stage type with a design speed of 35,000 rpm. The compressor turbine comprises two axial flow stages and the free power turbine has one axial flow stage. The combustion chamber is of the annular type, and fuel is admitted as a rotary spray from the main rotor shaft. The engine has an overall length of 60.482 in., excluding the air intake cone, and a typical installed weight of 440 lbs.

Write in No. 337 on Reader Service Card

NAVIGATION AIDS
based on Doppler Effect

Continuous measurement of ground speed, drift angle and distance covered can be obtained from the airborne, self-contained systems in a line of navigation devices based on the Doppler Effect. In addition, when one of them, the AD2300, is equipped with the proper computer, it can also indicate wind speed and direction, magnetic variation, miles left on a selected leg, and other factors, says **Marconi's Wireless Telegraph Co., Ltd., Dept. S/A, Marconi House, Chelmsford, England.**

The AD2300, especially designed for commercial aircraft, operates at an altitude of 50 to 50,000 ft and a ground speed of 80 to 900 kt. The AD2100's ranges are 150 to 50,000 ft for altitude and 65 to 400 kt, or 120 to 800 kt, for speed. Those of the AD2000 are 400 to 60,000 ft, and 100 to 700 kt. The AD230 uses an FM/CW transmitter-receiver system, and the others, both military types, a centimetric type with common T and R waveguide system.

Write in No. 338 on Reader Service Card

AIR FREIGHTER
serves dual function

The design of this heavy-duty transport permits its use in both military and commercial applications. The Universal, the commercial type, has all the virtues of the military version, the Beverley, and it is an exceptionally economical aircraft, says **Blackburn & General Aircraft, Ltd., Dept. S/A, Brough, E. Yorks, England.**

Four Bristol Centaurus engines give the cargo aircraft a 242-mph max. speed, and the ability to carry a 22-ton payload. Service ceiling is 16,000 ft and the runway length for take-off and landing (50-ft altitude) is 970 and 860 yds, respectively. For short range passenger operations, the aircraft can be rigged for 160 passengers, while medium range flights are better served with a 125-seat layout.

Write in No. 339 on Reader Service Card

ROCKET ENGINE
has small volume

Small volume and a variable thrust adjustable between 1102.5 and 7497 lbs distinguish the SEPR 81A rocket engine, which is particularly well suited to aircraft use, says **Société d'Etude de la Propulsion par Reaction, Dept. S/A, 37 Rue des Acacias, Paris 17, France.** Total weight of the engine and accessories is 353 lbs, and extensive use has been made of light alloy parts.

The engine, which uses nitric acid as an oxidizer, is unaffected by altitude, and it will take 50 flights without a check-up. It is fitted with a turbopump and electric starter, and is designed for pushbutton operation. All starting and checking operations are automatic.

Write in No. 340 on Reader Service Card

TRANSPORT
has 1400-mile range

Two Rolls-Royce Dart 2100-ehp engines give the Dart Herald transport a 275-mph cruising speed and a 1400-mi range, says **Handley Page, Dept. S/A, Cricklewood, London N.W.2, England.** The turboprop branchline aircraft is designed for rapid conversion to accommodate passengers, passengers and freight, or freight alone, and it can carry up to 47 passengers.

Maximum payload is 10,160 lbs. Good slow-speed handling and low tire pressure permit use of the aircraft on marginal airstrips. Take-off to 50 ft can be accomplished in 725 yds, and rate of climb at sea level is 1580 ft/min.

Write in No. 341 on Reader Service Card

SERVO ALTIMETER
is very sensitive

A servo altimeter that will contribute to greater accuracy and aircraft safety uses something new in altimeter presentation, says **Smiths Aircraft Instruments, Ltd., Dept. S/A, Cricklewood, London, N.W.2, England.** A counter shows altitude to the nearest 50 ft and a pointer makes one revolution of the dial for each 1000 ft; a counter in the lower part of the dial shows ground pressure setting.

Design is based on a pressure-sensitive capsule assembly that reacts to barometric height changes in a manner resulting in much greater sensitivity and almost negligible system lag. An accuracy of plus or minus one mb is provided over the whole range. The capsule also accurately follows rates of climb and descent in excess of 10,000 fpm. Capsule and all mechanisms are housed in the panel-mounted instrument, and its anti-vibration mounted amplifier may be installed in any convenient place.

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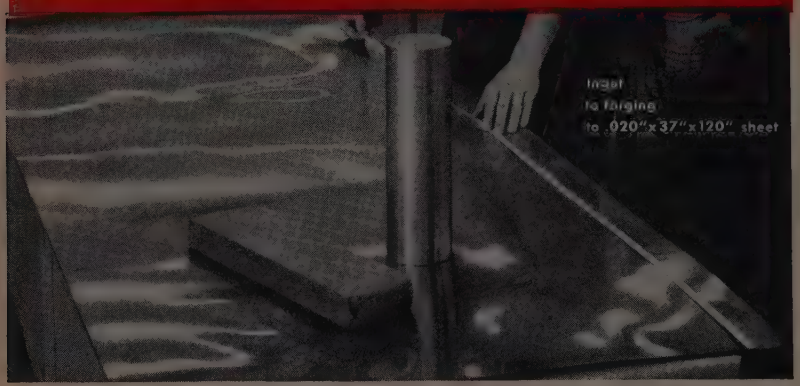
more on next page

2 MORE FANSTEEL SPACE-AGE ALLOYS with High Strength-To-Weight at HIGH TEMPERATURES



FANSTEEL 80 METAL

Alloy—Columbium-zirconium

Melting Point—4350°F.

Density—
8.6 grams per cc (0.311 lb. per cu. in.)

Tensile Strength—
Annealed 70°F.; 47,000 psi.

Stress-To-Rupture—
100 hr. 2000°F.
(argon) 18,800 psi.
500 hr. 2000°F.
(argon) 11,000 psi.

Other Properties—Ductile to brittle transition temperatures in annealed state are well below room temperature.

Advantages and Uses—Extremely high strength-to-weight ratio for high temperature applications. Excellent weldability, ductile welds with little or no tendency to fracture in heat affected zones. Easy fabrication at room temperature, as worked or annealed. For missiles, rockets, spacecraft, other high heat applications.

FANSTEEL 82 METAL

Alloy—Columbium-tantalum-zirconium

Melting Point—4550°F.

Density—
10.26 grams per cc (0.371 lb. per cu. in.)

Tensile Strength—
Annealed 70°F.; 55,000 psi.
2000°F. in air; 29,600 psi.
2400°F. in air; 11,700 psi.

Stress-To-Rupture—
100 hr. 2000°F. (argon) 17,500 psi.
500 hr. 2000°F. (argon) 13,500 psi.

Other Properties—High oxidation resistance compared to pure refractory metals. Oxide film is tenacious, non-volatile, tends to form protective coating. 16-hour, 2000°F. tests in flowing air show remarkably low scaling of 0.01 cm.

Advantages and Uses—Exceptionally suitable for air-frames and certain missile applications. Provides desirable strength-to-weight advantages at higher temperatures plus the same workability, weldability and ductility of Fansteel 80 Alloy.

AVAILABLE in ingots, forgings, bar, rod, plate, sheet and fabricated parts.
Write for latest technical bulletins.

FANSTEEL
HIGH TEMPERATURE METALS

K5942

FANSTEEL METALLURGICAL CORPORATION North Chicago, Ill., U.S.A.

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PULSE TRANSFORMERS are molded miniatures

One-in. long molded pulse transformers and chokes suitable for most pulse circuits are being made by **Murphy Radio, Ltd., Dept. S/A, Welwyn Garden City, Herts, England.** The small size allows the components to be wired into a circuit in the same way as resistors and capacitors.

Either a rigid synthetic polyester resin or Castoflex, a flexible casting and impregnating resin is used for the molding material, which completely seals the component against moisture. Cores are molded from a manganese-zinc ferrite material with a saturation density of 4000 gauss at 20 deg C. High Q values can be obtained up to 0.5 mc, and the maximum inductance is ten H.

Write in No. 310 on Reader Service Card

SERVO VALVE is electro-hydraulic

Electrical error detection and hydraulic output manipulation are combined in an electro-hydraulic servo valve made by **The Fairey Aviation Co., Ltd., Dept. S/A, Hayes, Middlesex, England.** The valve is controlled by a torquemotor, mounted integrally with the valve, and it delivers output hydraulic flow related to input electrical current.

The servo valve has been used in systems requiring pressures from zero to 4000 psi, and it has been driven from thermionic and magnetic amplifiers. Flow rate of present models is about 1.8 gpm, imperial. The device has proven useful in the operation of aircraft control surfaces and the control of machine tools, among other applications.

Write in No. 311 on Reader Service Card

SEXTANT DEVICE cuts navigation errors

A reference unit that does away with the bubble shift problem in aircraft periscopic sextants under conditions of vibration has been developed by **Kelvin Hughes (Aviation), Ltd., Dept. S/A, Winchester Rd., Basingstoke, Hampshire, England.** The device provides a stable datum measurement for obtaining the angle subtended by a celestial body and the horizon at the point of observation.

It consists of a tiny mirror suspended from a hairlike monofilament of nylon and contained in a temperature-compensated capsule filled with silicone oil. When subjected to vibrations in excess of operational requirements, the device showed a maximum recorded error of three min of arc. The unit is fitted to the sextant by a simple bayonet-cap arrangement.

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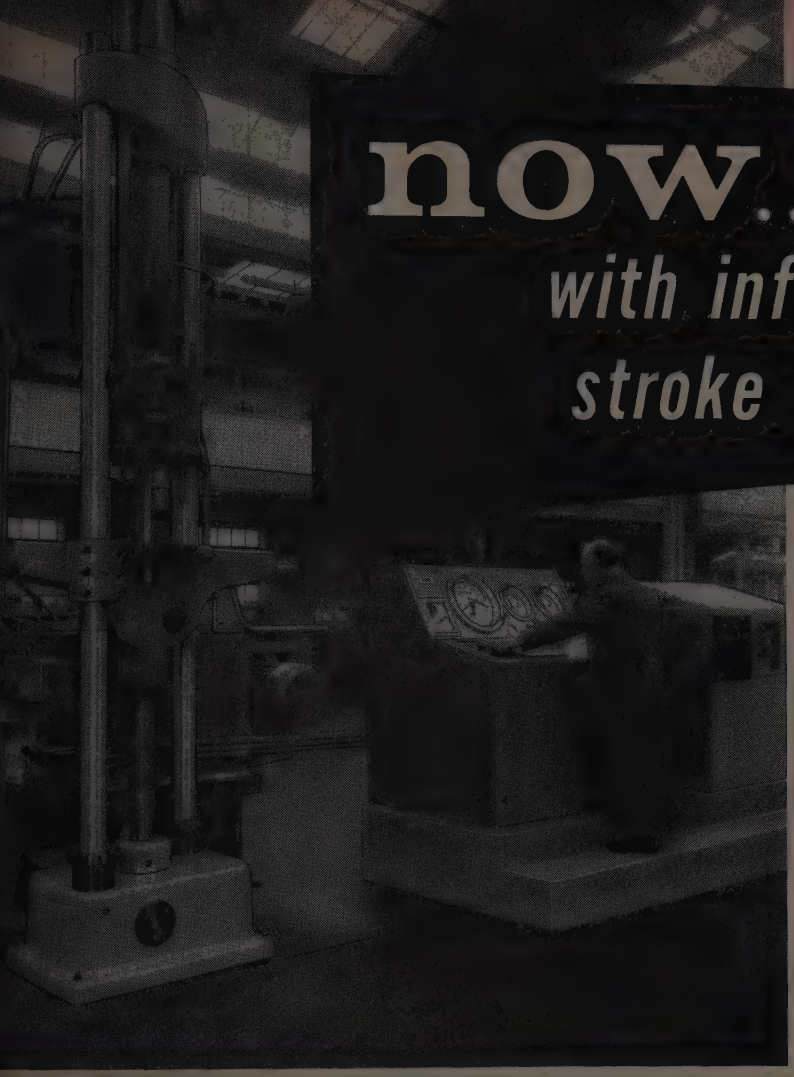
more on page 212

Write in No. 146 on Reader Service Card



now...fatigue testing with infinitely variable stroke and frequency

LOSENHAUSEN HYDRAULIC FATIGUE TESTING MACHINE WITH PROGRAMMER.

NEWLY AVAILABLE from Riehle, this Losenhausen hydraulic fatigue testing machine permits complete load and cycle flexibility. Consisting of a console, pulsator and loading unit cylinder, the Losenhausen machine generates strokes up to 10″ at low frequencies and modest strokes can be accommodated at frequencies approaching 1000 cpm.

The console measures and indicates the load developed on each cycle, as either fluctuating in tension or compression or as alternating between maximum compression and tension.

A programmer that automatically controls frequency, load and stroke can also be supplied. Another valuable Losenhausen advantage, this precise method of setting up tests save time and eliminates step-by-step errors.

FOR ENTIRE ASSEMBLIES

Simply through the use of general purpose testing cylinders, the Losenhausen machine can fatigue test full-scale assemblies and large components. These cylinders apply individual loads at various points.

Standard machines have dynamic capacities ranging from 12,000 to 200,000 pounds. Machines of higher capacity are special. General purpose testing cylinders are available in dynamic capacities from 2,000 to 100,000 pounds.

OTHER RIEHLE TESTING MACHINES:

Hydraulic and Screw Power Universal Testing Machines, Construction materials, Impact, Brinell, Torsion, Horizontal Chain, Rope and Cable Testing Machines, Portable Hardness Testers for Rockwell Readings, Etc.

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American Machine and Metals, Inc.

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"One test is worth a thousand expert opinions"

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Please send free catalog on Losenhausen Fatigue Testi
Machines. I'd also like information on

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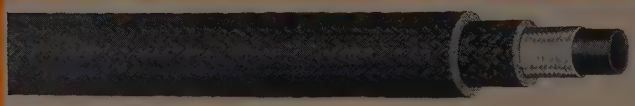
Fluoroflex®-T (Teflon®) HOSE & ASSEMBLIES

engineered for **SAFETY, RELIABILITY**

HIGH PRESSURE, HIGH TEMPERATURE HOSE for service from –65° to +400°F. Dash 4 through –8 sizes in bulk or to specifications with swaged fittings qualified for 3000 psi systems.

MEDIUM PRESSURE, HIGH TEMPERATURE HOSE for up to 1500 psi service from –100° to +450°F. Dash 3 through –24Z sizes qualified to MIL-H-25579. Available with swaged type or Seal-Lock fittings.

FIREPROOF HOSE, complies with FAA requirements. Construction: Fluoroflex-T tube; AISI Type 304 stainless steel wire braid; specially impregnated asbestos shield, Dash 3 through –24Z with swaged type or Seal-Lock reusable fittings.



PROPELLER FEATHERING HOSE, complies with FAA requirements. Construction: Fluoroflex-T tube; AISI Type 304 braid; two impregnated asbestos shields with intervening air spaces. Available with swaged or Seal-Lock fittings.

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®Teflon is DuPont's trademark for TFE fluorocarbon resins.

Originators of high temperature fluorocarbon hose assemblies

Resistoflex CORPORATION Dept. 256

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AIRBORNE COMPUTER is entirely self-contained

Altitude, rate of climb, Mach number and indicated airspeed can be computed by this electromechanical analog computer from pitot and static pressure measurements, says **Kelvin Hughes (Aviation), Ltd., Dept. S/A, Winchester Rd., Basingstoke, Hampshire, England.** The air data computer is completely self-contained; it has its own power pack and plug-in transistor amplifiers.

Reliability and ease of maintenance are featured in the unit, which can also be designed to give a true airspeed output. A typical computer has the following ranges: .3 to three Mach; 80 to 700 kn indicated airspeed; –1000 to 100,000 ft altitude; and ±60,000 ft/min rate of climb.

Write in No. 370 on Reader Service Card

MISSILE is anti-aircraft weapon

A solid-fuel motor powers this close-range surface-to-air missile, which will replace the British Navy's 40mm gun as the standard close range weapon. The Seacat will also serve as anti-aircraft armament for small ships, says **Short Brothers & Harland, Ltd., Dept. S/A, Queen's Island, Belfast, Ireland.**

The weapon is small and highly maneuverable, and it is designed to be instantly ready to attack. The test vehicle used for preliminary research on the Seacat is reported to have shown remarkable stability in flight.

Write in No. 371 on Reader Service Card

TINY MOTOR for small servo systems

A 1.6-in. motor, one of the smallest of its type in existence, is suited for use with small servo systems, such as those in guided weapons, according to **Smiths Aircraft Instruments, Ltd., Dept. S/A, Cricklewood, London, N.W.2, England.** The Size 7 motor is fully potted and built with non-corrodable laminations. No-load speed is 9000 rpm, and stall torque is eight gm/cm.

The motor may be driven from a single phase, 26-V supply, or from a two-phase, 400 cps supply. One type can be operated directly from a pair of germanium transistors.

Write in No. 372 on Reader Service Card

more on page 214

. . . missile handling is faster, more precise with hydraulic power by VICKERS®

Looking for a better drive to Move missiles from storage to launchers . . . to Aim missiles precisely . . . to Guide or Track missiles? Then consider these features of a Vickers hydraulic drive:

Ultra fine control — missile launchers and radar drives have been trained and elevated with exceptional accuracy down to speeds approaching zero.

Fast positioning — the fastest acceleration, deceleration and reversal of any power transmission.

High power gain — one milliwatt input easily controls hundreds of horsepower.

Narrow deadband — narrower than any other high horsepower drive.

Excellent efficiency — overall mechanical efficiency of hydraulic transmissions (motor and pump) can exceed 85% at full load.

Consider, too, these other advantages — unusual compactness . . . packaged units . . . extreme reliability.

If your missile handling problem is urgent, phone, wire or write for further information or an immediate visit by one of our application engineers.

For more than fifty years, we have worked on applications ranging from the largest gun turrets to missile launchers. So, tell us about your drive problem. There is an excellent possibility that we have already developed the units that will fit your needs.

Write for your free copy of Bulletin 5303, "Vickers Hydraulics for Missile Systems."

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DIVISION OF SPERRY RAND CORPORATION
Marine and Ordnance Department
WATERBURY 20, CONNECTICUT

Hydraulic Products for Marine and Ground Defense Applications

MO-212A

DISTRICT SALES OFFICES: DETROIT, MICHIGAN • EL SEGUNDO, CALIFORNIA • BERKELEY, CALIFORNIA • WASHINGTON, D.C.

Write in No. 148 on Reader Service Card at start of Product Preview Section

Eliminates antenna shading

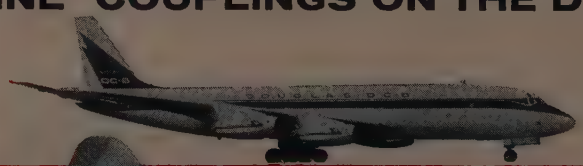
Autonetics' new *Automatic Antenna Selector* insures uninterrupted radio reception in military and commercial aircraft. Used with dual-antenna systems, it assures a strong, continuous signal. Does away with manual switching and losses due to coaxial tees in the antenna feedlines. Simple to install... has a 10,000-hour operating life with minimum maintenance ...completely reliable during high-speed maneuvers and in environmental extremes. Meets stringent military requirements.

Autonetics

A Division of North American Aviation, Inc., Downey, California

ON MARK COUPLINGS

NEW ON MARK FLEXIBLE LINE COUPLINGS ON THE DC-8



Standard equipment on the Douglas DC-8 fuel lines is ON MARK's new Flexible Fluid Line Couplings. Vastly superior to old style "AN" tube unions, this new coupling has been tested far beyond the requirements of specification MIL-C-25014 with simultaneous flexure, axial motion and pressure cycling at −65°F. WITH NO DEVIATION. Simpler in design, easy to assemble (NO SPECIAL TOOLS NEEDED), and lighter, the ON MARK coupling seals on deformed, marred and scratched tubing at all temperatures. Tests prove these couplings to be equally effective for special requirements such as hot air, gases, exotic fuels, and vacuum.

In production in standard tubing sizes.

For full information please contact

ON MARK COUPLINGS, INC.

4440 York Boulevard, Los Angeles 41, California

Telephone CLinton 4-2278

Representatives: Airsupply Company, Beverly Hills, Calif.; Aero Engineering Company, Mineola, Long Island, N.Y.; Divisions of The Garrett Corporation;

Write in No. 149 on Reader Service Card at start of Product Preview Section

MOTORS & GENERATORS for planes and missiles

A variety of motors and tach-generators, ranging from Size 15 to 45 have been developed for the aircraft and missile field by **Evershed & Vignoles, Ltd., Dept. S/A, Acton Lane Works, Chiswick, London, W4, England.** The components have outputs from ½ to 100 W and they cover the range of operational frequencies from 12½ to 1100 cps.

The company line also includes high-frequency hysteresis motors and dc constant speed motors, as well as specialized test units, such as the T.U.16 rotary power unit for the ground testing of missile systems. Accurate performance analysis of the various servo systems may be obtained with the Evershed dual channel quick response recorders.

Write in No. 373 on Reader Service Card

ANALOG COMPUTER has modular design

Available modular units permit this electronic analog computer to take on any desired size or complexity, says **The Fairey Aviation Co., Ltd., Dept. S/A, Heston, Middlesex, England.** The basic arrangement contains a control rack, which houses control and distribution equipment for up to 96 operational dc amplifiers.

The computing panel of the device holds 12 standard dc amplifiers and the front of the panel is compartmented to accept units that provide a wide range of linear and non-linear mathematical functions. Computer design permits the display or recording of solutions on multi-channel cathode ray oscillographs, direct writing recorders, or X-Y plotters.

Write in No. 374 on Reader Service Card

ILS SYSTEM aids automatic landings

An automatic landing system that brings jet bombers and other aircraft to as close as 70 ft above the runway has the advantage of requiring no speech communication between ground and aircraft, says **Pye Telecommunications, Ltd., Dept. S/A, Newmarket Rd., Cambridge, England.** It thus eliminates language difficulties, risks of misinterpretation, and other sources of human error inherent in GCA systems.

After the aircraft is at 70 ft, auxiliary equipment completes the touchdown. The ILS system also aids manual landings by giving a pilot-interpreted course from 30 mi out, right to the runway bar lighting. The equipment is being used as the standard approach aid for Royal Airforce V-bombers, Comets, and Canberras.

Write in No. 375 on Reader Service Card

more on page 216

TAG-108 and AR-108...

A NEW APPROACH TO VHF Ground-Air Communications...

The TAG-108 and AR-108 is designed specifically to surpass existing FAA, Canadian Department of Transport and ICAO specifications.

TRANSISTORIZED ENCAPSULATED CIRCUITRY

FEATURES

AR-108 VHF Receiver

- Single crystal channel, 108-156 Mcs.
- Completely transistorized
- Modularized plug-in circuitry
- Compact size—permits two units to be mounted side-by-side in std. 19" rack
- Low power drain and heat dissipation
- Indefinite component life expectancy
- Simplified servicing and testing procedures

TAG-108 VHF Transmitter

- Two crystal channels with 1 Mcs. spacing over 108-156 Mcs. frequency range
- Up to six channel simplex operation with common power supply
- Adjustable power output from 10 to 50 watts A3 emission
- Built-in speech compressor

RCA INTERNATIONAL DIVISION
RADIO CORPORATION OF AMERICA
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Trademark(s) Registered

VEST POCKET POWER

From vest-pocket nuclear generators for ocean, arctic and wilderness stations—or satellites and space systems—to portable power reactor systems meeting the large-scale requirements of military installations, the products of Martin's five-year nuclear development program are now making news... Developed under the direction of the AEC, the pint-sized 4-pound Martin SNAP III thermo-electric generator was recently singled out for commendation by the scientific community. Meanwhile, Martin is at work on a portable nuclear power plant, designed for transport by air, to provide power and heat for an Air Force installation at Sundance, Wyoming.

MARTIN

BALTIMORE · DENVER · ORLANDO

The Nuclear Division is one of the seven divisions of The Martin Company

ALLOYS improve parts

Rep. 6 and Rep. 14 are two alloys in a line developed to satisfy the requirements of low weight, small bulk, and high efficiency in aircraft components, according to **Messier, Dept. S/A, 6 Av. Raymond-Poincare, Paris 16, France.** Notable improvements in parts originally designed for conventional alloys are said to be the result.

Rep. 6, which possesses excellent fatigue limits and tensile strength, as well as a higher elastic limit, is ideal for parts subjected to both high static stresses and high alternating loads. Rep. 14, a heat-resistant alloy, may be used for parts operating at temperatures between 150 and 250 deg C.

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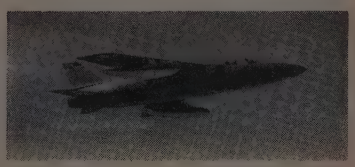
FIGHTER is lightweight



An operational weight of about one-third of its contemporaries is featured in the Gnat Mark 1 single-seat transonic fighter aircraft, says **Folland Aircraft, Ltd., Dept. S/A, Hamble, Southampton, England.** Thrust-weight ratio of the turbojet permits a climb rate of 50,000 ft in five min, from brakes-off.

Level speed is Mach 0.98, and endurance is two hrs. Another aircraft, the Gnat two-seater transonic trainer, also a turbojet, has been designed for good level-speed performance and very easy handling. Controls and instruments are fully duplicated, and hydraulic failure may be simulated for training purposes. Total internal tankage is over 260 gals.

Write in No. 377 on Reader Service Card

BRAKE REGULATOR is very light

Minimum bulk and very light weight (35 to 42 oz) are design features of the Ministop aircraft brake regulator, says **Messier, Dept. S/A, 6 Av. Raymond-Poincare, Paris 16, France.** In most cases it can be housed inside the undercarriage axle for protection against weather.

The regulator assures versatile brake operation. For example, it permits braking after take-off and before retraction of the undercarriage. It also enables brakes to be applied before touchdown. Operation will not cause resonance in the undercarriage or in the aircraft in yaw or pitch.

Write in No. 378 on Reader Service Card

more on next page

TEST EQUIPMENT ENGINEERS

If you've been looking for an opportunity to explore new engineering territory, the positions now open in our electronics test equipment group may be right down your alley.

We need engineers to do research and development based on an entirely new electronics test equipment philosophy. Briefly, the job involves design of test equipment and analysis of electronics designs submitted by vendors and subcontractors. This is one phase of our work on advanced weapon systems B-70 and F-108.

A BSEE, plus experience, can qualify you.

For more information please write to: Mr. P. F. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 15, Calif.

THE LOS ANGELES DIVISION OF
NORTH AMERICAN AVIATION, INC.

HELICOPTER takes six-ton load

A helicopter that seats forty-two passengers or carries a six-ton load is the largest twin-turbine, mechanically-driven helicopter of single-rotor configuration built in the Western world, says **Westland Aircraft, Ltd., Dept. S/A, Yeovil, England.** The Westminster is offered in the Crane-Transporter version, which permits external carrying of loads, and a civil transport type.

Both types use two Napier Eland turbines with a maximum continuous power rating of 2605 shp. The Crane-Transporter is 89 ft three in. long, and it has a 14,000-lb disposable load, including fuel and payload. Its cruising speed is 100 kt, and it has a vertical rate of climb—on both engines — of 130 ft/min. The civil transport type cruises at 130 kt, has a 390 naut m range (over double that of the Transporter), and its vertical rate of climb is 920 fpm. Its fuel and payload limit is 11,355 lbs. Overall length is 86 ft nine in.

Write in No. 383 on Reader Service Card

CONTROL SYSTEM for large transports

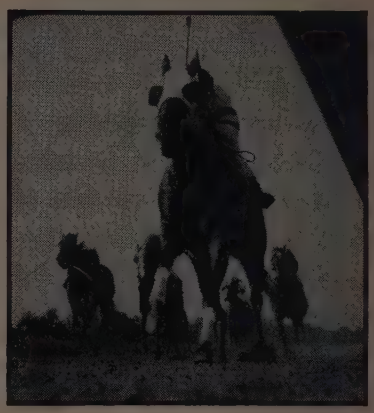
Simplicity and safety have been embodied in a flight system for the control of large aircraft, says **Smiths Aviation Div., Dept. S/A, Kelvin & Hughes Ltd., Cricklewood, London, N.W.2, England.** The system includes an automatic pilot, two beam compass indicators, two director horizons, duplicate signaling gyro verticals, radio selector, and standby magnetic compass.

Switching and setting operations are common to both the flight director and the autopilot. This permits the autopilot to be monitored by reference to the flight director, and it simplifies transition from automatic to manual flight. The SEP.2 autopilot is said to provide positive control under all operation conditions and over the entire speed range of modern aircraft. It provides for coupling to ILS and VOR beams, fully automatic approach down to 200 ft; height lock, and other features. It has been installed on all versions of the Comet and Britannia, among other aircraft.

Write in No. 384 on Reader Service Card

more on page 220

IT'S THE FINISH THAT COUNTS



IN TUBING TOO!

TESTS PROVE PRECISION FINISH UNSURPASSED

Shape, size, alloy are important in tubing and Precision Tubing excels in all . . . but finish is an outstanding quality of Precision Tubing where specified . . . and at no extra cost.

Precision Tubing is available in clean, scratch-free finishes suitable for anodizing or plating to mirror finishes. In sizes from .010" to 1.125" O.D. in copper, brass, aluminum, up to ⅝" O.D. in nickel and nickel alloys.

Other Precision Tubing is available in straight lengths, coils, preformed to specified shapes . . . and also as Coaxitube the metal shielded coaxial conductor. Whatever your designs or requirements for fine accurate tubing at regular tube prices order Precision Tubing. Write for complete technical data to Dept. 10, Precision Tube Company, Inc., North Wales, Pa.

GET THIS NEW TUBING DATA CATALOG . . . FREE!

PRECISION TUBE COMPANY

Write in No. 153 on Reader Service Card

New Johns-Manville Tadpole Packing

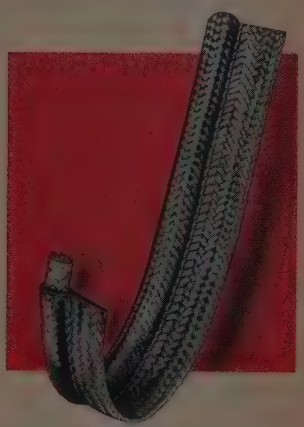
first to withstand 1500 F blast from jet "braking" mechanism!

WHEN today's airliners roar in for a landing, they depend on a reverse-thrust mechanism to act as a "brake" by diverting the searing jet blast as they hit the runway.

Finding a comparatively soft packing for this reverse-thrust mechanism—one that could repeatedly "bounce back" to seal effectively after being compressed—and being hit by extreme temperatures and velocity—was a problem that plagued the aircraft industry.

New Johns-Manville Tadpole Packing solved the problem. It is made entirely of specially processed wire, knitted metallic mesh, refractory fiber, and a core designed to prevent filtration of gases. Today it is standard equipment on the new jet airliners.

This is another example of J-M Packing Research at work for American industry. Whether you need a packing for plant machinery, aircraft, automotive or marine equipment . . . Johns-Manville can supply the right packing for the job. If you would like further information, write Johns-Manville, Box 14, New York 16, New York.



This J-M Tadpole Packing does an effective sealing job under light pressures and despite temperatures to 1500 F. It maintains high recovery that assures an effective, lasting seal between light metal parts.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

Write in No. 154 on Reader Service Card at start of Product Review Section

A *NEW* Dependable PRESSURIZATION UNIT

Check these features:

- DRY AIR TO – 85°C DEWPOINT. SELF-REACTIVATING
- CONTINUOUS, CLEAN (oil-free) AIR for life
- HIGH and LOW PRESSUE SYSTEM ranging from 15 psia to 80 psia.
- INDICATORS and INTERLOCKS provided for high and low pressure systems.
- HIGH IN PERFORMANCE, LIGHT IN WEIGHT. Suitable for airborne or ground support application.

Exclusive drying method uses two automatic self-reactivating dehydrators. Unit is lubricated and grease packed for a minimum life of 1000 hours. Model 101-018 is representative of a series of "packaged assembly units" consisting of qualified components that have been designed and developed over the years by Great Lakes.

Let us show you how you can save time and money by incorporating existing units in your design plans at an early stage.

Some of the complete line of products designed and manufactured at Great Lakes

High Pressure FUEL PUMP | *High Temperature* DEHYDRATOR | PRESSURE SWITCH | *High Volume* COOLANT PUMP

Write today, for complete information on Great Lakes PNEUMATIC-FUEL-HYDRAULIC Components. An experienced Sales Engineer is available to discuss your requirements.

GREAT LAKES

MANUFACTURING CORPORATION

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Write in No. 155 on Reader Service Card

REINFORCED PLASTICS in preimpregnated form

All normal types of laminating resins, glass reinforcements, and other reinforcements based on Nylon, Orlon, and Terylene are available in preimpregnated form, according to **Aeroplastics, Ltd., Dept. S/A, Hillington, Glasgow, S.W.2, Scotland.** The preimpregnation is said to improve shelf life, ease of handling, and reduction in production time.

Controlled variable tack and drape for ease of build-up, and controlled variable molding or fabricating properties are other advantages. Polyesters, epoxies, silicones, and phenolics are among the materials used. They can be cured by conventional methods at pressures of 10 to 200 psi and temperatures of 200 to 280 deg F.

Write in No. 385 on Reader Service Card

NAVIGATION AIDS include radio compass

A subminiature airborne radio compass for the frequency range between 200 and 800 kc is one of a variety of navigation and communication devices made by **Elliott Brothers (London), Ltd., Dept. S/A, Borehamwood, Hertfordshire, England.** The 10.5-lb E-RCB-2, which combines radio receiver and control unit, also includes an automatic loop antenna, indicator, and power unit.

Other available aircraft aids include the E-TA-21A VHF transmitter, a 14-lb, 360-channel transistorized device with 50-kc spacing and 25-Wrf output, and the eight-lb E-RA-21A VHF receiver, which has 500 channels. The E-NVA-21A navigation aid provides localizer and complete, automatic VOR facilities when used with the E-RA-21A. The fully transistorized unit weighs 9¼ lbs. Light weight is also featured in marker and glide slope receiver equipment.

Write in No. 386 on Reader Service Card

SCATTER AMPLIFIER for uhf communications

A 10-kw amplifier is being used in tropospheric scatter links to provide reliable UHF communications over distance of up to 250 mi in a single hop, says **Marconi's Wireless Telegraph Co., Ltd., Dept. S/A, Marconi House, Chelmsford, England.** The Type HS 313 amplifier is used in conjunction with a single drive unit, and spaced receiving antennas and a two-path receiver permits dual diversity operation.

The amplifier consists of a water-and-air cooled klystron which, along with its power supplies, is housed in four free-standing cubicles. The system permits automatic run-up to full power from cold, and correct sequential operation is ensured by the use of preset timing units. Frequency ranges used are 400 to 525 mc, and 680 to 970 mc, or both, with separate klystrons for each range.

Write in No. 387 on Reader Service Card

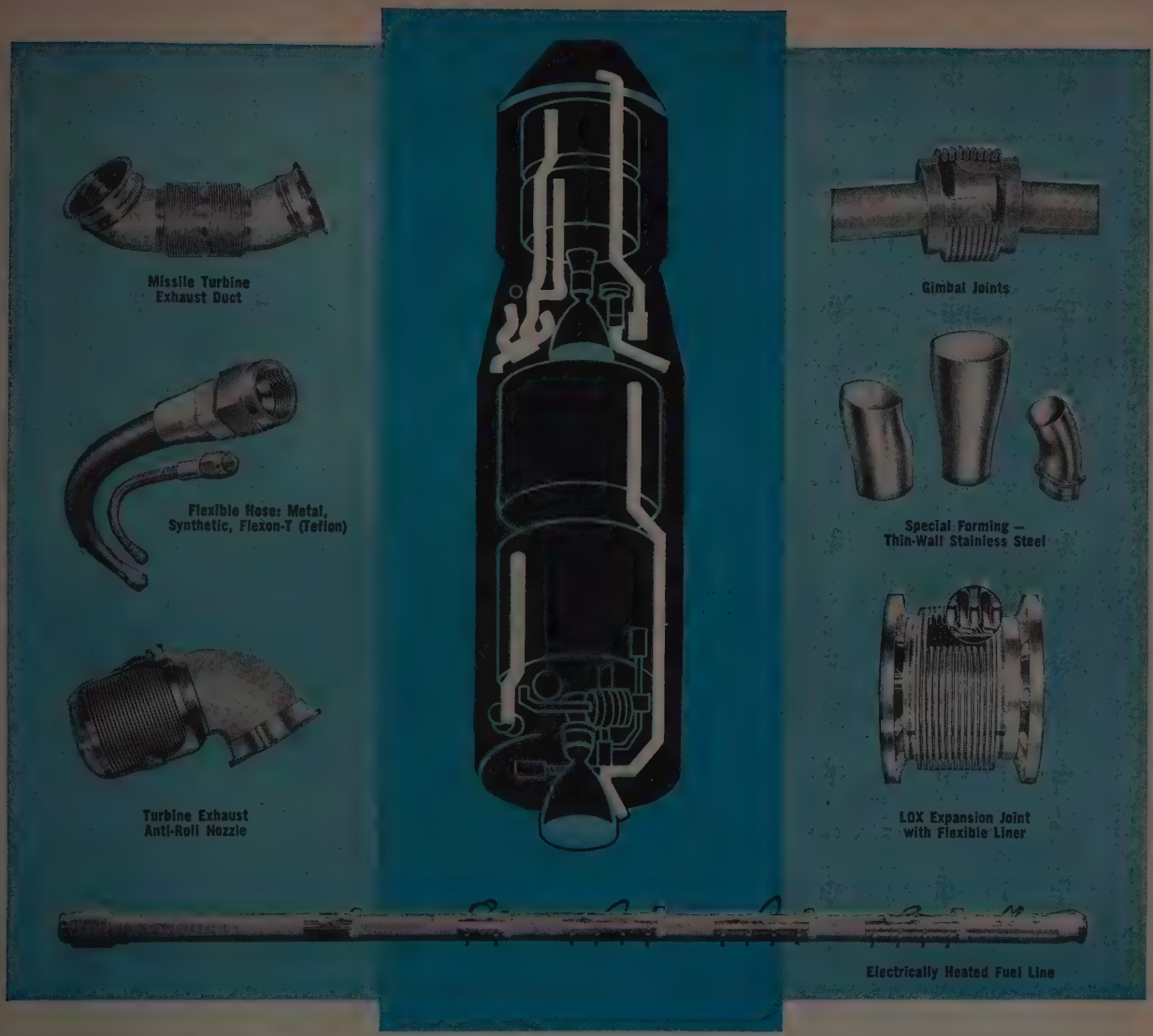
UHF RECEIVER in electronics line

A low noise receiver that covers the 420 to 470-mc range and has an overall bandwidth of four mc is among the electronic equipment made by **Sir W. G. Armstrong Whitworth Aircraft, Ltd., Dept. S/A, Baginton, Coventry, England.** The noise factor is about ten db and input impedance is 70 ohms.

The firm also markets a wideband directional coupler for measurement of RF power and SWR in coaxial cables. This device can be used to obtain optimum termination of a 52-ohm coax system for frequencies to 600 mc and a 72-ohm version is also available. A third product in the line is a single pole, double breaking switch for aircraft and industrial use.

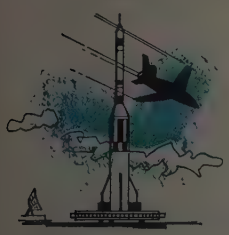
Write in No. 388 on Reader Service Card

more on page 222


Missile Turbine Exhaust Duct
Flexible Hose: Metal, Synthetic, Flexon-T (Teflon)
Turbine Exhaust Anti-Roll Nozzle
Gimbal Joints
Special Forming — Thin-Wall Stainless Steel
LOX Expansion Joint with Flexible Liner
Electrically Heated Fuel Line

Propulsion piping system or individual components . . .

FLEXONICS ENGINEERING AND EXPERIENCE CAN SERVE YOU BEST



Flexonics has pioneered, for over half a century, in precision-forming thin metals into flexible carriers for a variety of media . . . and still leads. This special talent of Flexonics engineers and designers is available to you in the development and manufacture of LOX, fuel, hydraulic, pneumatic and turbo exhaust systems.

For the most authoritative product and design recommendations covering ducting systems, flexible connectors, bellows, metal hose, and Flexon T (Teflon)—contact your Flexonics Sales Engineer or write for Flexonics Aeronautical Engineering Manual.

Flexonics

AERONAUTICAL DIVISION

FLEXONICS CORPORATION • 1350 SOUTH THIRD AVENUE • MAYWOOD, ILLINOIS

Divisions

INDUSTRIAL HOSE • EXPANSION JOINT • BELLOWS • AERONAUTICAL • AUTOMOTIVE

Flexonics Research Laboratories, Elgin, Illinois

In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

Write in No. 156 on Reader Service Card at start of Product Preview Section

HELICOPTER
is cold-jet type

Economy, design simplicity, and reliability are realized from the use of jets of compressed air to operate the main rotor of the Fiat 7002, a medium capacity, two-bladed helicopter designed for passenger transport and general duty. These and other advantages are obtained because no fuel burns in the compressed air, which is applied at the blade tips says **Aviation Div., Fiat, Dept. S/A, Corso Giovanni Agnelli 200, Torino, Italy.**

A Type 4700 turbo-generator supplies the compressed air, and the air compressor and primary engine are mechanically independent. This permits choice of a compression ratio that corresponds to the best pneumatic transmission efficiency. The helicopter can carry seven persons, including pilot, and the useful load is about 1760 lbs. It has a skid-type landing gear.

Write in No. 220 on Reader Service Card

AIRCRAFT BEACONS
in varied line

A wide variety of devices relating to the aircraft field is being produced by **Ultra Electric, Ltd., Dept. S/A, Western Ave., Acton, London, W.3., England** Among them are CW, UHF and VHF beacons for bearings, and rescue beacons for 500 kc, with facilities for HF, VHF and UHF modules.

Other devices in the line include radar simulators, computing devices, gas turbine controls, transistorized power units, and electronic servo amplifiers.

Write in No. 221 on Reader Service Card

TRANSMITTER LINE
is extensive

VHF and UHF transmitters with special FM and pulse modulator systems for research into missile control and countermeasure operations are among the units produced by **Ultra Electric, Ltd., Dept. S/A, Western Ave., Acton, London, W.3., England** High-power command link transmitters, together with subminiature receivers, have also been designed.

The company line also includes a comprehensive system for vehicle control and communication, as well as special communications systems.

Write in No. 222 on Reader Service Card

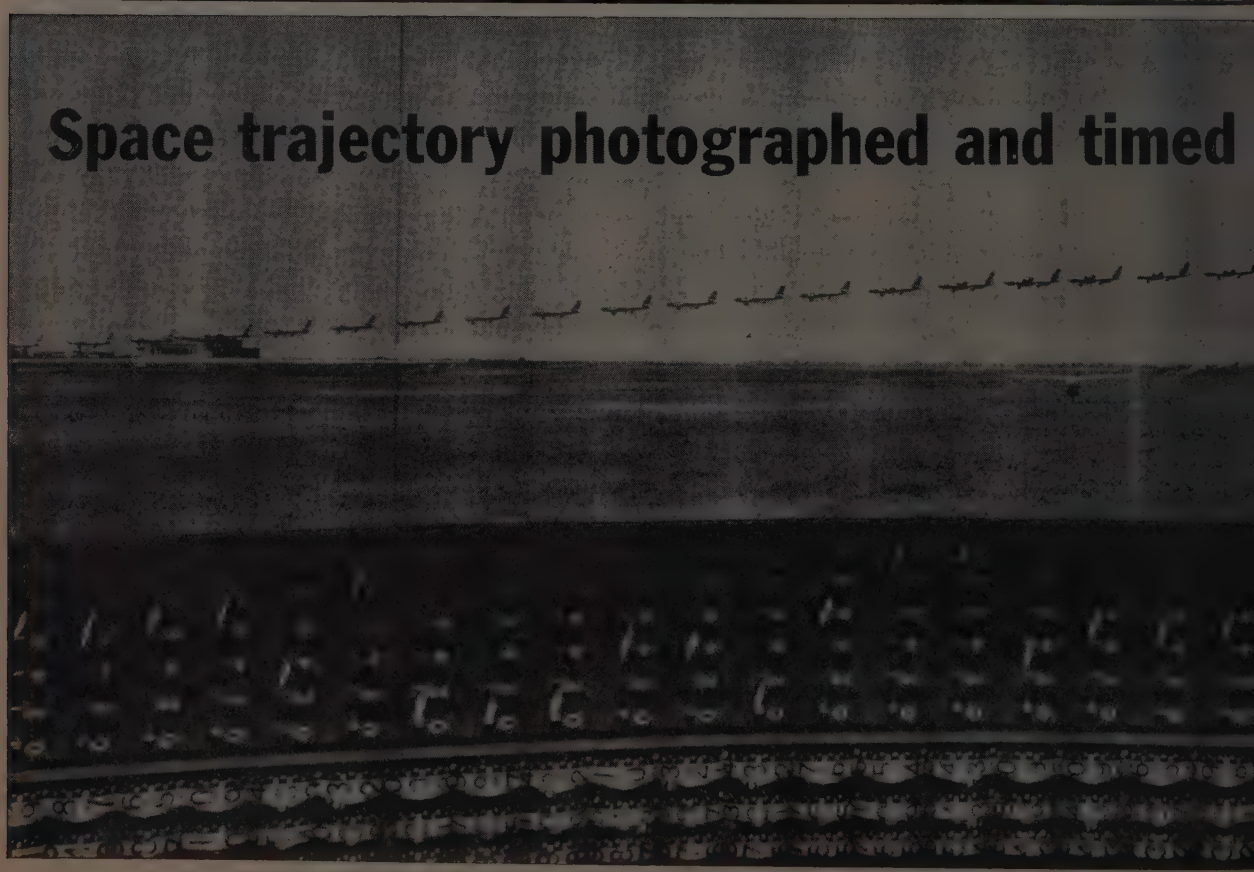
FREIGHT TRANSPORT
has very large fuselage

The Britannic long-range freighter is a turboprop aircraft with a fuselage that is 17½ ft in diameter and that has clear hold dimensions of 12x12x80.5 ft, says **Short Brothers & Harland, Ltd., Dept. S/A, Queens Island, Belfast, Ireland.** The high-wing monoplane uses four Rolls-Royce Tyne engines, and its design relies heavily on the standard Britannia.

The aircraft can carry a 75,000-lb payload for 1400 mi and do so at 360 mph, or it can, fully fueled, transport 30,000 lbs for over 5500 mi. A rear ramp-loading door controlled by hydraulic rams simplifies vehicle loading, and a side door in the fuselage at the forward end of the hold facilitates the loading of small freight.

Write in No. 223 on Reader Service Card

Space trajectory photographed and timed



PUMP
for high pressures

Pressures of 3000 to 4000 psi in normal operation are ensured by these aircraft pumps, says **Messier, Dept. S/A, 6 Av. Raymond-Poincare, Paris 16, France.** They are reliable under temperature variations and will operate at altitudes up to 65,000 ft.

Other features include excellent endurance and maximum economy in weight.

Write in No. 224 on Reader Service Card

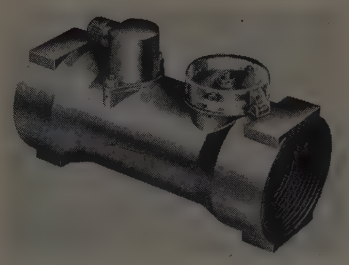
POWER SUPPLY
for servo amplifiers

This transistor power supply operates from 115 V, 400 cps, and is capable of delivering up to 30 W dc, says **S. G. Brown, Ltd., Dept. S/A, Shakespeare St., Watford, Herts, England.** The unit, primarily designed to power up to two Brown 6.5-W transistorized servo amplifiers, provides full output at ambient temperatures of up to +90 deg C.

Auto-transformers are used in the unit because of space considerations, and the dc output is floating. Ripple voltage of the 16½-oz. device is under 0.5 per cent, with a 50-mfd parallel capacitor, and full to no load regulation is better than eight per cent.

Write in No. 225 on Reader Service Card

FUEL METER
has high flow rate



An aircraft fuel flow meter with a maximum flow rating of 300 lbs/min has been designed for installation in the low-pressure side of the fuel system, says **George Kent, Ltd., Dept. S/A, London, England.** The MAT 4801 is an inferential-type meter equipped with a magnetically-operated transmitting mechanism, and it works in conjunction with a remote indicator to give rate of flow combined with total quantity.

Variations in specific gravity of the fuels are compensated for by a device built into the 1.5-lb meter. The metering mechanism makes impossible any flight hazard if the rotor jams or flow is obstructed. Meter capacity ranges from 15 to 300 lb/min.

Write in No. 226 on Reader Service Card

TEST STAND LINE
is comprehensive

Piston, jet and turboprop test stands are included in the comprehensive range of test stand equipment made by **John Curran, Ltd., Dept. S/A, Curran Rd., Cardiff, Great Britain.** Among them is the Type T Mark II for turboprops of up to 7000 shp, a device that accepts both engine and propeller, unlike conventional equipment using electrical or hydraulic dyanmometers.

The Type J Mark 1C thrust measuring stand has a capacity of 25,000 lb of thrust and, by virtue of its cantilevered support arm, is particularly useful in handling modern engines with top pick-up points. Another interesting unit in the line is the Type J Mark 1 mobile test stand for airport testing of turbojets with up to 12,500 lb thrust. A primary attraction is that it can be brought in for on-site use where construction of permanent test beds is not feasible. The Type W is designed for medium and high power piston engines, and it uses the principle of power absorption by test fan or flight propeller for an accurate assessment of in-flight conditions.

Write in No. 227 on Reader Service Card

more on next page

on a single record!

Fairchild Flight Analyzer records a photo-graph with 58 images, appearing at equally spaced intervals along the trajectory.

The Fairchild Flight Analyzer lowers data reduction costs while providing a high order of accuracy of basic data. It actually eliminates three of the major disadvantages inherent in many instruments currently in use for space movement recording: 1. their inability to track at high azimuth rates; 2. the high cost of reducing data; 3. time delays pending outcome of previous runs.

What the Analyzer does

The Fairchild Flight Analyzer produces a record which is a true, undistorted graph, self-plotted by the object at a constant scale. Simultaneously, a timing record is superimposed on the base of the picture strip by an auxiliary lens (see photo). The engineer gets an immediate "quick look" at data on attitude, position and relative time, all on a single record.

Records actual angular data

Unlike a cine-theodolite, which records a fore-shortened, vari-sized image, the Flight Analyzer records a true space position and attitude. Thus, all angular data is actual and requires no correction. Data gives smooth curves permitting determination of velocity to within 1 mph or less, and accelerations of 0.5 ft/sec/sec.

For complete 24-page technical manual on the Fairchild Flight Analyzer, write to Industrial Products Division, Dept. 15, Fairchild Camera and Instrument Corporation, 5 Aerial Way, Syosset, L. I., N. Y.

Represented in the 11 Western States by Gordon Enterprises, 5362 N. Cahuenga Blvd., No. Hollywood, Calif.

INDUSTRIAL PRODUCTS DIVISION

FAIRCHILD

CAMERA AND INSTRUMENT CORPORATION

Write in No. 157 on Reader Service Card at start of Product Preview Section

NEW ENDEVCO
VIBRATION
SYSTEMS
Featuring: Transistorized charge amplifier and hermetically sealed accelerometer. You can use up to 300 feet of cable between amplifier and accelerometer —with no signal loss.
Complete Endevco system qualifies to Mil E-5272. Temperature range —40° F to +230° F. Frequency response from below 10 cps to above 10 KC. Entire system isolated from ground.
Endevco System Amplifiers and Transducers are described in the "2200" and "2600" literature. Write for your copies today.
dynamic instrumentation
ENDEVCO CORPORATION
Department M
161 East California Boulevard
Pasadena, California
Write In No. 161 on Reader Service Card at start of Product Preview Section

PRODUCT PREVIEW

FLOW METERS minimize variations

The fuel flow measuring devices in this line include an integrator and two flow meters for aircraft use. Both flow meters make use of remote indicators, minimize viscosity variations, compensate for variations in density, says **Negretti & Zambra, Ltd., Dept. S/A, 122 Regent St., London W.1, England.**

The Series 2 fuel flow meter maintains the integrated reading to plus or minus two per cent of integrated quantity, when the average rate of consumption is not less than 20 per cent of full scale reading. The integrator, a direct-reading cyclometer type, has been incorporated in the Series 2 flow meter. It gives a full-scale reading of 100,000 kg of fuel in intervals of ten kg, and it is driven, through reduction gearing, by a low-inertia integrating motor designed for negligible friction.

Write in No. 230 on Reader Service Card

SONOBUOY has long range

These sonobuoys can transmit their radio signals over a 20-naut mi range when the receiving aircraft is at 2000 ft, says **Ultra Electric, Ltd., Dept. S/A, Western Ave., Acton, London, W.3, England.** An aircraft altitude of 500 ft halves that range.

The submarine detecting devices are five ft long and are equipped with small parachutes for aerodynamical stability. They can be dropped from 150 to 10,000 ft at an aircraft speed of 150 to 250 kn.

AM output, on 61 mc, is 200 mw. Power supplies for the devices consist of a two-V lead-acid accumulator and a 145-V Kalium battery for the electronic equipment, and a separate 14.7-V Kalium for driving the motor, which permits a rotation of three rpm.

Write in No. 231 on Reader Service Card

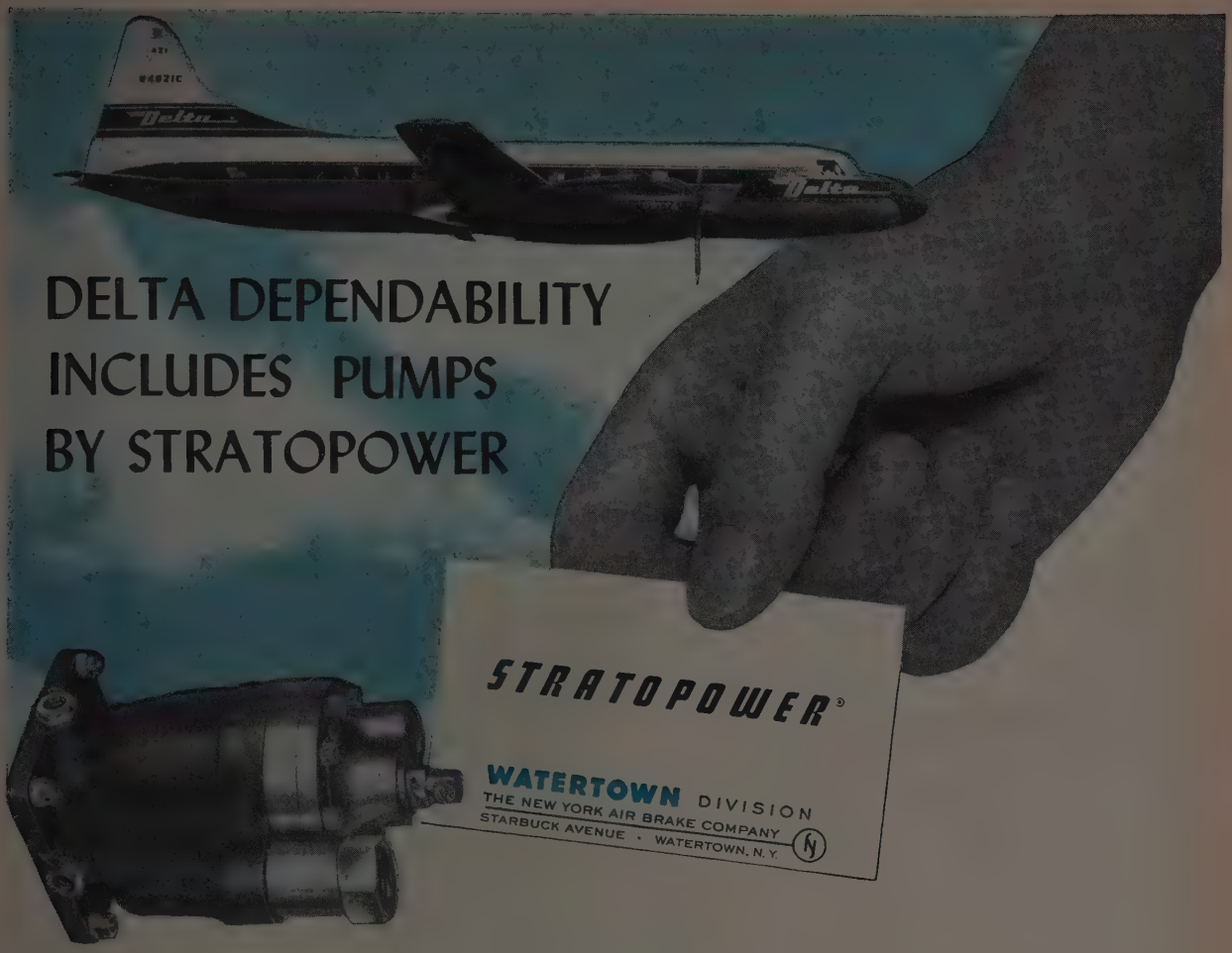
POTENTIOMETERS are very accurate

The Series 5000 low-torque precision potentiometers are designed for applications such as telemetering, servomechanisms, and computers, says **S. G. Brown, Ltd., Dept. S/A, Shakespeare St., Watford, Herts, England.** Linear accuracy is held to .1 per cent.

The device can provide up to 35 precise fixed tappings to facilitate adaptation to non-linear law requirements. High load dissipation, low starting torque, and resistance to corrosion are other features. The potentiometer rotates at 120 rpm and has a life expectancy of one million revolutions. It dissipates 15 W at 20 deg C and has a temperature range of −60 to +150 deg C.

Write in No. 232 on Reader Service Card

more on page 228



DELTA DEPENDABILITY INCLUDES PUMPS BY STRATOPOWER

STRATOPOWER is making a major contribution to the dependable service offered by Delta Airlines, Inc. Here is an example in specific facts and figures provided by Delta from service records.

These records show, for a group of 50 STRATOPOWER Model 66WA300 pumps, an average service life of over 5000 hours each up to the time this advertisement was prepared.

Superior design, meticulous manufacturing procedures and a deep understanding of industry needs for engineering and service have made this record a reality. Some pumps have accumulated 8000 hours of service; others undoubtedly have many thousands of hours to go before major parts replacement becomes necessary.

STRATOPOWER appreciates the privilege of serving outstanding companies such as Delta Airlines, Inc., and is continually striving, through research and development of advance designs to extend the frontiers of hydraulic equipment performance.

The hydraulic pumps, motors, packages and systems being designed at STRATOPOWER today will continue the dependability PLUS contribution to aircraft performance in the years to come.

For the finest hydraulic equipment and *satisfaction* of your hydraulic needs, see your nearest STRATOPOWER representative.

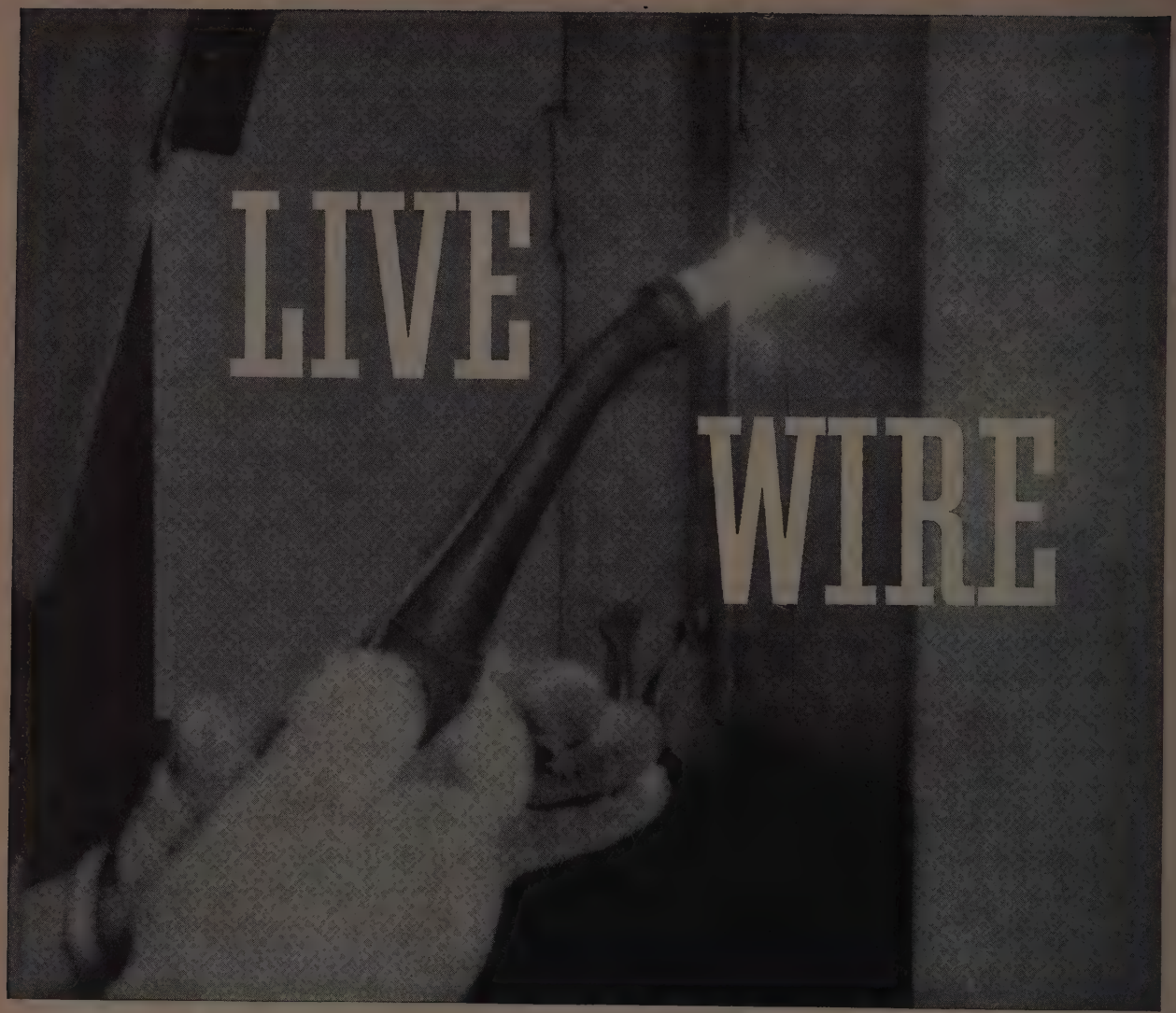
DALLAS OFFICE
The New York Air Brake Company
3323 Grove Street
Dallas 35, Texas

LOS ANGELES OFFICE
The New York Air Brake Company
5058 Venice Boulevard
Los Angeles 19, California

SEATTLE OFFICE
The New York Air Brake Company
Post Office Box 318
Bellevue, Washington

WATERTOWN DIVISION
THE NEW YORK AIR BRAKE COMPANY
STARBUCK AVENUE • WATERTOWN • N. Y.

Write in No. 160 on Reader Service Card at start of Product Preview Section



New design in Sigma hand welding torches

Here is a new, lightweight torch—only 16 ounces—for manually welding light-gage steels. Sigma ST-2 welds in all positions with no change in control or current settings. Welds .030- to .100-in. sheet, using low-voltage short-arc technique with .020- and .030-in. hard-drawn wire. For 200 amp continuous service, a-c or d-c.

Balanced design makes handling easy. Service lines enter through rear of handle—a convenience in cramped quarters. Start-stop switch on handle, easy to reach. Nozzle has a 60° curve for maximum weld visibility.

Sigma ST-2 makes high-quality welds at high speed. Seams require no cleaning . . . distortion is at a minimum. Inert gas shielding is economical. Low flow rate—only 10 cu. ft. or less per hour—means even more savings.

Call your nearest LINDE office today for a demonstration of this new Sigma ST-2 torch! Or write Dept. **J-6,** LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. Offices in other principal cities. In Canada: Linde Company, Division of Union Carbide Canada Limited.

Linde
TRADE-MARK

UNION CARBIDE

"Linde" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Write in No.167 on Reader Service Card at start of Product Preview Section

THEY CREATE THE IMPOSSIBLE—WITH ALCOA ALUMINUM

Not long ago, many of the components routinely turned out by the Franklin Balmar Corporation, of Baltimore, *would* have been quite impossible to fabricate—at *any* price.

They specialize in components of extreme intricacy—machined to precise tolerances. The components of the new Boeing B-52 wing, machined by Balmar as subcontractor for Fairchild Aircraft, are typical of the highly demanding work turned out by these precision "sculptors in aluminum."

Severe sculpturing can be performed satisfactorily only on aluminum of the highest quality. For this reason, Franklin Balmar must have top quality and dependable uniformity in the aluminum it uses. Alcoa has been able in all cases to satisfy these unusual requirements. This is why Alcoa® Aluminum is Franklin Balmar's first choice.

For Alcoa Aluminum alloys are predictably uniform. Alcoa 7178 alloy, for instance, in the wing panels of the B-52 fuel tank. Or any *other* Alcoa alloy. You can trust it to behave exactly the same, time after time. Once you've developed a production routine, you know it will produce identically reliable results continuously.

Another reason for Balmar's preference for Alcoa Aluminum is its high internal quality—an important consideration in work where the cost of machining may be many times the cost of the raw metal itself. A hidden flaw might ruin a piece *after* hundreds of dollars' worth of machining operations have been completed!

Preference for Alcoa Aluminum by Franklin Balmar Corporation is something—we hope—that should justify a similar preference on *your* part, when the need next arises. Contact our sales offices or write us for information: Aluminum Company of America, 2027-F Alcoa Building, Pittsburgh 19, Pa.

For Exciting Drama Watch "Alcoa Theatre," Alternate Mondays, NBC-TV, and "Alcoa Presents," Every Tuesday, ABC-TV

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

Your Guide to the Best in Aluminum Value

Write in No. 159 on Reader Service Card at start of Product Preview Section

CHROMALOX
FLEXIBLE AND MOLDED ELECTRIC HEATERS

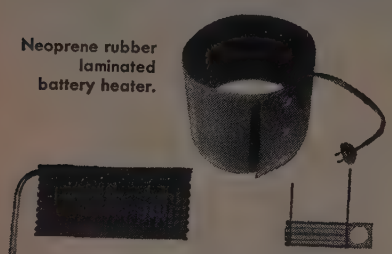
Electronic heating harness molded to fit small object. Three woven heaters molded in high temperature refractory and aluminum case (left) and glass and polyester resin (center and right). Small thermostat is molded to base of center heater.

Neoprene rubber molded heater, eliminates ice clogging of aircraft pitot tube.

Silicone rubber laminated heater molded on a 2½" spherical radius. Two of these completely cover and protect guided missile storage battery reservoir.

Silicone rubber laminated heater bonded to a metal component for an aeronautical camera.

Neoprene rubber laminated battery heater.



Woven heaters. Temperatures to 800°F. Any size or shape up to 24" wide and to any length. Can be supplied with eyelets, snap fasteners, mounting holes. Moisture and abrasion resistance can be provided by silicone rubber coating.

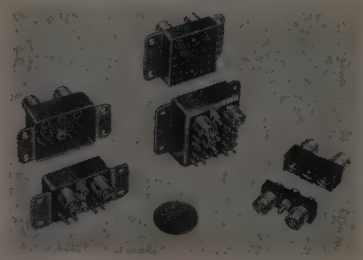
Chromalox Flexible and Molded Heaters are shaped-to-fit to put exact amounts of heat where it is needed.

FREE—Send today for new Bulletin J-1003 which gives detailed engineering information. Or, call your Chromalox Representative for personal assistance with any heating problem. 91812

CHROMALOX Electric Heat
INDUSTRIAL • COMMERCIAL • RESIDENTIAL
EDWIN L. WIEGAND COMPANY
7775 THOMAS BLVD., PITTSBURGH 8, PA.

Write in No. 163 on Reader Service Card

CONNECTORS for miniature equipment



Domino Unitors, which are designed to interconnect electronic units on miniaturized equipment make possible various pin combinations and arrangements with'n the same chassis cut-out, says **Belling & Lee, Ltd., Dept. S/A, Great Cambridge Rd., Enfield, Middx., England.**

The basic Domino units include: double coax plug and socket; two-pin plug and socket; eight-pole plugs and sockets; and a 12-pole plug and socket.

Write in No. 233 on Reader Service Card

more on next page

As easy as plugging in your electric shaver...

Wherever you use compressed air...

...just

PLUG IN THE POWER

- Tough...compact...smaller...lighter.
- Handles more air—with minimum pressure drop.
- Quick connection and disconnection.
- Instant automatic flow or shut-off.
- Handles any job in your shop using ¾" to ⅛" connections—from the air line to the air tool.
- Locking ring provides positive lock ... tight fit. Equipped with automatic sleeve lock.
- All Series 2-RL Sockets and Plugs are interchangeable—likewise all Series 3-RL Sockets and Plugs. Eliminates all need for various size couplings in hook-up—makes it easy to keep stock of parts in balance—holds inventories to a minimum.

with the HANSEN Series RL QUICK-CONNECTIVE Ring-Lock Coupling

Socket, when disconnected, automatically shuts off air by leak-proof seal of metal valve against rubber valve seat.

Write for the Hansen Catalog...
a ready reference when you want information on couplings in a hurry.

Quick-Connective Fluid Line Couplings for
AIR • OIL • GREASE • HYDRAULIC FLUIDS
WATER • VACUUM • STEAM • OXYGEN • ACETYLENE
REFRIGERANTS • GASOLINE • COOLANTS • LP-GAS

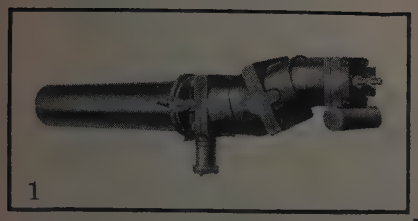
SINCE 1915
REPRESENTATIVES IN PRINCIPAL CITIES
QUICK-CONNECTIVE FLUID LINE COUPLINGS

THE HANSEN MANUFACTURING COMPANY
4031 WEST 150th STREET • CLEVELAND 35, OHIO

Write in No. 164 on Reader Service Card at start of Product Preview Section

EFFICIENT, COMPATIBLE AUXILIARY POWER SYSTEMS...

designed and built by VICKERS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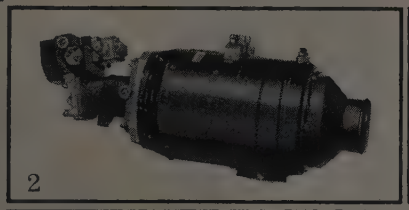
Missile progress demands unquestionable reliability, maximum efficiency and compatibility of the system with the overall vehicle. These rigid standards are being met by Vickers with *missile industry-tailored* R & D, engineering, production and service capabilities blended with extensive experience gained from a large number of successful accessory applications on a majority of the current production missiles.

Typical Vickers designed APS's include:

1. Hot Gas Systems
2. Close Frequency Systems
3. Battery Powered Systems
4. Door Mounted Systems
5. Blast Tube Configurations
6. Turbine Powered Systems
7. Flywheel Systems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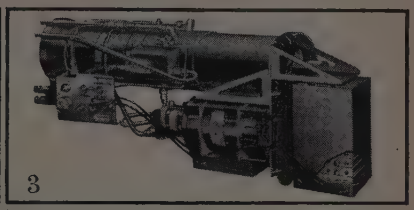
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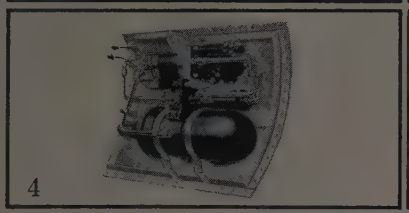
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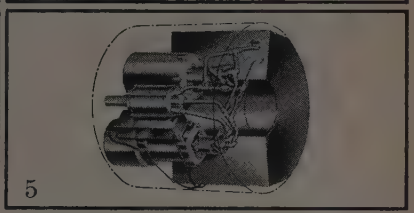
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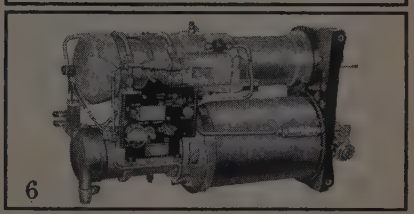
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7

Using proven components as building blocks, Vickers can shorten APS development time and speed delivery . . . all with the assurance of dependability. These advantages are passed on to you whether your specifications call for one or any combination of the following:

- TEMPERATURE TOLERANT SYSTEMS
- MAXIMUM EFFICIENCY
- CLOSE FREQUENCY CONTROL
- HIGH SPECIFIC POWER
- HIGH OR LOW DRIVE SPEEDS
- ACCURATE VOLTAGE REGULATION

For further information contact the nearest Vickers Sales and Service Office or *write for Bulletin No. A-5236.*

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION

Aero Hydraulics Division — Engineering, Sales and Service Offices:

ADMINISTRATIVE and ENGINEERING CENTER
P. O. Box 302 • Detroit 32, Michigan

TORRANCE, CALIFORNIA
3201 Lomita Blvd., P.O. Box 2003 • Torrance, Calif.

Aero Hydraulics Division District Sales and Service Offices:
Albertson, Long Island, N.Y., 882 Willis Ave. • Arlington, Texas, P. O. Box 213 • Seattle 4, Washington, 623 8th Ave. South • Washington 5, D.C., 624-7 Wyatt Bldg.
Additional Service facilities at: **Miami Springs, Florida, 641 De Soto Drive**
TELEGRAMS: Vickers WUX Detroit • TELETYPE: "ROY" 1149 • CABLE: Videt
8239 OVERSEAS REPRESENTATIVE: The Sperry Gyroscope Co., Ltd.—Great West Road, Brentford, Middx., England

Engineers and Builders of Fluid Power Equipment Since 1921

Write in No. 165 on Reader Service Card at start of Product Preview Section

FOR OPTIMUM PROTECTION FROM VIBRATION / SHOCK / NOISE

utilize LORD capabilities

Greater reliability—*your* problem? LORD can help you do something about it. Protective mounting systems, designed, tested and produced at LORD, insure high reliability for sensitive equipment.

LORD is a diversified, capable technical organization, supported by modern facilities and prepared to complete challenging assignments in controlling vibration, shock and noise.

Your project can benefit from experience gained in working on Atlas, Talos, Jupiter, B-58, F-105, F11F, Convair 880, ground support, vehicular, shipboard, submarine and other advanced classified projects.

LORD is ready to work as an integral member of your team.

LORD MANUFACTURING COMPANY · ERIE, PA.

FIELD ENGINEERING OFFICES

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NEW YORK, N. Y. · Circle 7-3326
PHILADELPHIA, PA. · PEnnypacker 5-3559
SAN FRANCISCO, CAL. · EXbrook 7-6280

"In Canada—Railway & Power Engineering Corporation Limited"

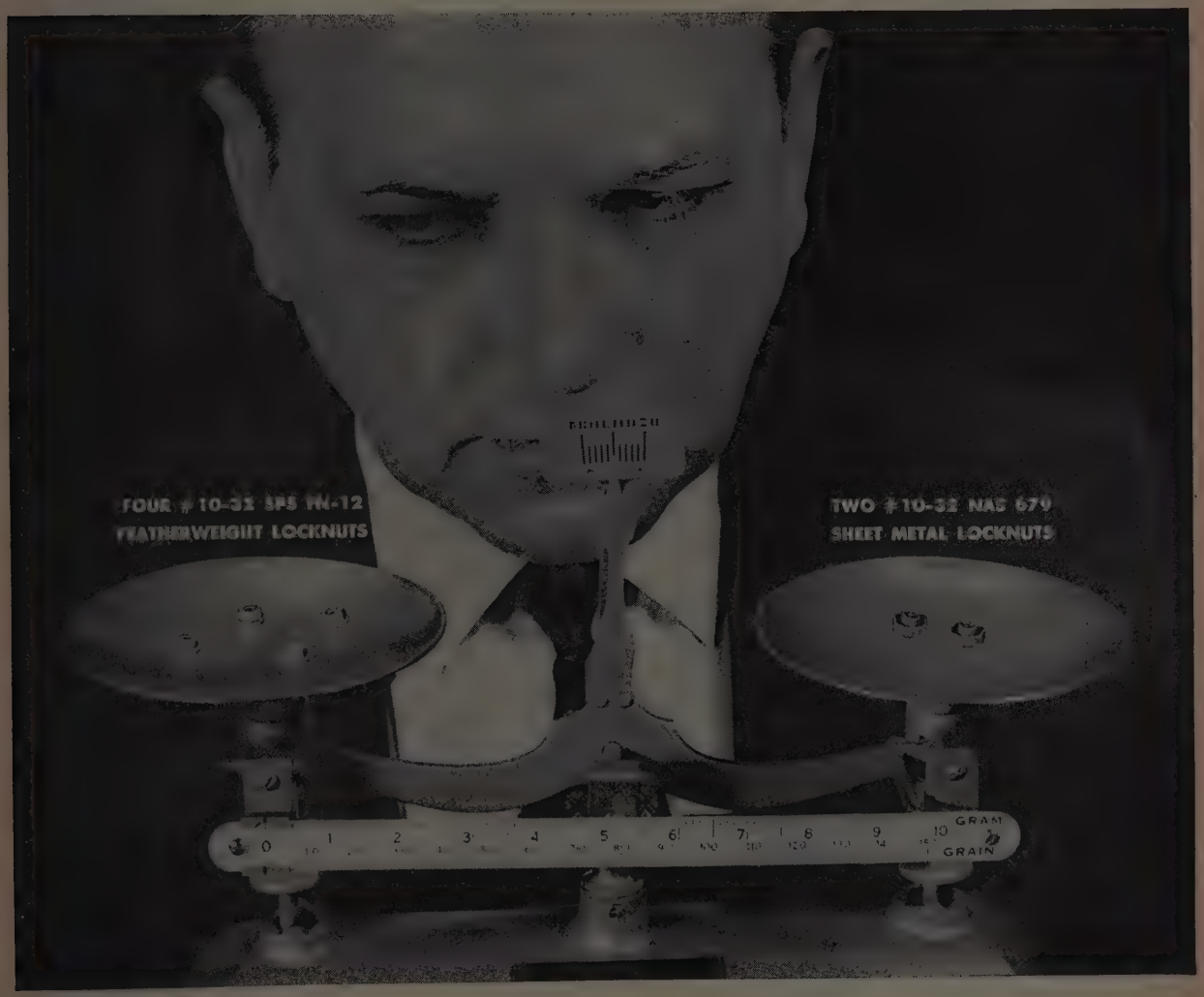
Write in No. 166 on Reader Service Card at start of Product Preview Section

New from SPS Laboratories

FN-12 Featherweight Locknut

NAS 679 replacement offers weight savings up to 60%

. . . available immediately in sizes #4 through 1 in.



This new forged featherweight locknut replaces widely used NAS 679 sheet metal nuts* and weighs 12-60% less. Price is practically the same or, in some sizes, lower. New configuration permits installation closer to vertical bulkheads, allowing additional weight savings through use of narrower flanges. Offers 160,000 psi tensile strength on 180,000 psi bolt. Available immediately in 11 sizes—#4 through 1 in. For new Bulletin 2426, write SPS—manufacturer of precision threaded fasteners and allied products in many metals, including titanium.

*Also interchangeable with MS 20364, MS 20365; NAS 1021, NAS 1022; AN 363, AN 364, AN 365 and AN Plain Nuts

AIRCRAFT / MISSILE Division **SPS**

JENKINTOWN 54, PENNSYLVANIA • SPS WESTERN, SANTA ANA, CAL.

Write in No. 162 on Reader Service Card at start of Product Preview Section

CUT OFF

IDL's Inertial Velocity Meter actuates the predetermined "cut-off" with an error of less than fifty feet at one hundred miles, or actuates the destructor circuit if range safety limits are exceeded.

The engineering and production experience which created this instrument has also been applied to other inertial control, telemetering and radar display systems and to data processing equipments.

These capabilities are fully described in IDL's Brochure, available upon request from the Customer Relations Department.

INSTRUMENT DEVELOPMENT LABORATORIES
INCORPORATED
67 MECHANIC STREET, ATTLEBORO, MASSACHUSETTS, U.S.A.

A Subsidiary of Royal McBee Corporation

Write in No. 168 on Reader Service Card at start of Product Preview Section

FORCE BALANCE is portable

This servo-operated force balance instrument has the merit of being a portable, extremely accurate, pressure measuring system, says **Kelvin Hughes (Aviation), Ltd., Dept. S/A, Winchester Rd., Basingstoke, Hampshire, England.** Lightness and ruggedness are combined with laboratory standard accuracy, and the system is suitable for flight test measurements, wind tunnel use, engine test bed work, and other applications.

Minor modification enables the device to transmit pressure measurement, and the instrument can also be adapted for use with corrosive fluids. Accuracy over normal pressure ranges and moderate ambient temperatures is about ±.05 per cent of the total range of pressure being measured.

Write in No. 234 on Reader Service Card

ENGINE LINE includes copter types

Engines for several types of aircraft are being manufactured by **D. Napier & Son, Ltd., Dept. S/A, London W.3, England.** The Eland propeller-turbine is made for medium range transports or helicopters, the Gazelle free turbine for helicopters, and the Scorpion liquid propellant rocket engine for high altitude interceptor aircraft.

The Eland is rated at 3500 ehp. It has a ten-stage axial-flow compressor and a three-stage reaction turbine. In helicopter applications, propeller and reduction gearing are removed, and drive shafts transmit turbine power to the rotor. The Gazelle is suitable for installation at any angle between vertical and horizontal, and it may be used for any helicopter requiring power outputs between 1260 and 2000 shp.

Write in No. 235 on Reader Service Card

SERVO AMPLIFIER is transistorized

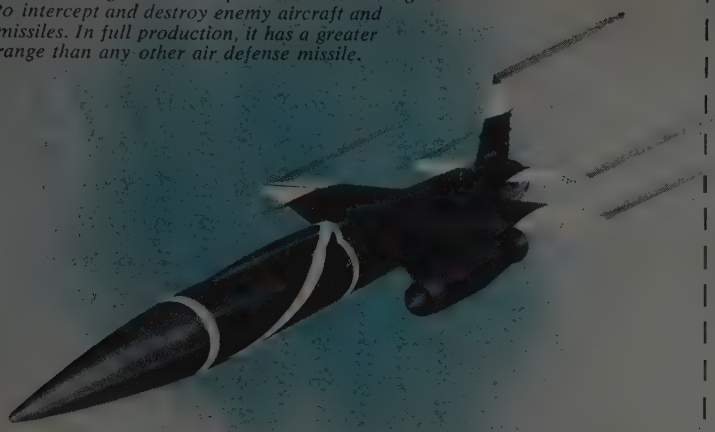
A fully-transistorized amplifier capable of rated output at ambient temperatures up to +90 deg C without the use of a heat sink has been primarily designed to operate in conjunction with the Type 15^{b} servomotor, says **S. G. Brown, Ltd., Dept. S/A, Shakespeare St., Watford, Herts, England.** The amplifier output stage introduces a controlled measure of viscous damping into the servomotor.

Overall power gain is 72 db when the amplifier operates from a source impedance of at least 250 ohms. The amplifier will operate from small signal sources, such as inductive pick-offs, and will also accept large signal inputs without degradation, as a result of its input limiter.

Write in No. 236 on Reader Service Card

more on page 234

THE BOEING IM-99 BOMARC . . . *is a long range, extremely high altitude supersonic missile designed to intercept and destroy enemy aircraft and missiles. In full production, it has a greater range than any other air defense missile.*



HI-TORQUE BOLT

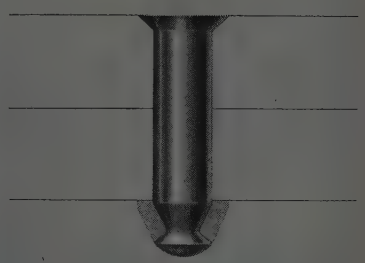
IDEAL FOR FASTENING STRESSED ACCESS AND CLOSE-OUT PANELS. ITS UNIQUE SHALLOW RECESS LOCKS THE DRIVER INTO IT WHEN A HIGH TORQUE LOAD IS APPLIED DURING INSTALLATION OR REMOVAL.

STRUCTURAL EFFICIENCY CONTRIBUTES TO GREATER PERFORMANCE

The airframe of the Bomarc reflects a successful solution to structural and fastening design problems typical to high performance missiles and aircraft. The airframe combines high strength with high temperature resistance, without adding unnecessary weight which could effect performance.

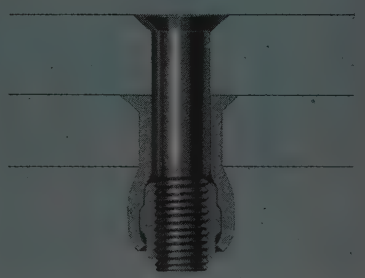
Three different fastener problems in the Bomarc are solved by stainless steel Hi-Shear fasteners. Hi-Shear Rivets are used in structure subjected to engine and rocket boost heat . . . Hi-Torque Bolts fasten removable panels and the nose section where heat, surface smoothness and ease of removal are factors. Blind Nuts eliminate hole/nut coordination problems in congested areas.

Continuing fastener environmental studies are being conducted at the Hi-Shear Test and Research Laboratories in a variety of strength and temperature resistant material combinations for advanced structural requirements.



HI-SHEAR RIVET

HAS THE LIGHTEST STRENGTH-WEIGHT RATIO, LEAST PROTRUSION AND LOWEST COST OF ANY SWAGED TYPE FASTENER. INSTALLED WITH STANDARD RIVET GUNS OR SQUEEZERS FITTED WITH HI-SHEAR RIVETING SETS.



BLIND NUT

FOR BLIND OR OPEN APPLICATIONS, THE BLIND NUT CUTS PRODUCTION COSTS BY USING ONE HOLE INSTEAD OF THE NORMAL THREE REQUIRED FOR NUTPLATES. INSTALLATION SPEED IS ABOUT TEN PER MINUTE BY ONE MAN USING A LIGHTWEIGHT, HYDRAULICALLY OPERATED GUN.

U.S. PATENT PENDING, FOREIGN PATENTS GRANTED AND PENDING.

"HI-TORQUE" TRADEMARK REGISTERED IN U.S. PATENT OFFICE. U.S. PATENTS NO. 2,477,985; 2,745,120 AND 2,752,039. U.S. PATENT PENDING.

"HI-SHEAR" TRADEMARK REGISTERED IN U.S. PATENT OFFICE. U.S. PATENTS NO. 2,355,579; 2,355,580; D-138-579; OTHER U.S AND FOREIGN PATENTS PENDING.

hi-shear RIVET TOOL COMPANY

2600 WEST 247TH STREET, TORRANCE • CALIFORNIA

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priceless

When your priceless test data are recorded on film, you will find no more reliable source of film processing than CFI. At CFI all of your film requirements... for sales, training, and visual aids, 16 or 35mm, will receive the most careful attention.

CFI UNDERSTANDS your film problems. CFI has processed the invaluable film records of many vital projects. CFI recognizes the need for uncompromising quality and fast action.

CFI FACILITIES are complete... and modern. CFI has developed many new processes and is the leader in its field. CFI has complete security clearance, assuring safe handling of highly classified material.

CFI EXPERIENCE includes 40 years as the nation's largest and most progressive organization, with complete lab facilities in both Hollywood and New York.

FOR COMPLETE INFORMATION on capabilities and service available, write or call for a sales representative.

cfi

CONSOLIDATED FILM INDUSTRIES
959 Seward St., Hollywood 38, Calif. • HO 9-1441
521 West 57th St., New York 19, N.Y. • CI 6-0210

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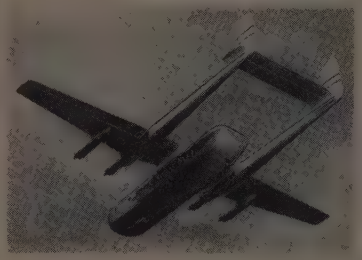
AIR FREIGHTER in several versions



Wide tail boom spacing and the Rolls Royce power plants of the Standard AW 650 Argosy Freightercoach have made possible a number of variations, according to **Sir W. G. Armstrong Whitworth Aircraft, Ltd., Dept. S/A, Baginton, Coventry, England.** Two versions are: the AW 670, a combination vehicle and passenger transport; and the AW 671, a short-haul passenger carrier.

The AW 650 itself is pressurized for operation over medium ranges, and its fuselage is narrower than that of the 670 Series. The AW 670 has a 15-ft wide, double-deck fuselage, and it will carry six cars and 30 passengers. The 671 will accommodate up to 126 passengers. Each of the three aircraft are equipped with four Dart 526 turboprop engines, each rated at 2100 ehp. Cruising speed of the basic twin tail boom 670 aircraft is 230 kt, and range is 200 nautical mi.

Write in No. 237 on Reader Service Card

TRANSPORTS designed with twin booms

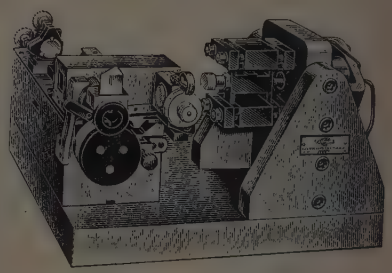
A common wing, twin booms, tailplane, and turboprop engines are featured in three new aircraft in a new family of transports, says **Sir. W. G. Armstrong Whitworth Aircraft, Ltd., Dept. S/A, Baginton, Coventry, England.** Different sizes and shapes of payload container account for variations between aircraft.

The Argosy is a short or medium range freightercoach with a pressurized fuselage, and it is capable of lifting 13½ short tons of freight or 80 passengers. Except for a rear door that opens during flight to permit supply dropping, the AW 660 military transport is similar to the Argosy. The third aircraft is an unpressurized two-decker available as the Air Ferry or Airbus. It has a wider fuselage than the Argosy, and in the A.W. Air Ferry version, its lower deck will accommodate six large cars; the upper deck holds 30 passengers. The Airbus seats 96 passengers on the lower deck and 30 on the upper. The aircraft are designed for use on routes up to about 350 mi long.

Write in No. 238 on Reader Service Card

more on page 236

Vibration Interferometer



For extremely precise checking and calibration of accelerometers

Accurate vibration test equipment is essential in pin-pointing weaknesses in missiles and rockets . . . weaknesses that can cause deviation from flight paths or even complete destruction of the vehicle. The new Gaertner Vibration Interferometer is specifically designed for extremely accurate calibration of accelerometers used to measure vibration of completed assemblies, subassemblies, and individual piece parts under environmental tests.

Because the amplitudes of vibration are of the order of a few millionths of an inch, the interferometer principle is used. Interferometry employes the wavelength of light as the basis of measurement. This extreme precision enables the accelerometers to be calibrated to values that permit them to be used as secondary standards.

The Vibration Interferometer consists of three major components: the Interferometer, a Multi-Beam Stroboscopic Slit Assembly with white light source, and a Vibrator. Frequency range is approximately 450 to 10,000 cycles. Double amplitudes over a range of one to 1,000 micro-inches can be determined to an accuracy of 10^{-6} inch, or 1%, whichever is greater. If you already have a vibrator and associated electronic equipment, it may be possible to adapt these to the Gaertner Interferometer and Strobe Slit units.

Write for Bulletin 204-59

designers and manufacturers of precision optical measuring instruments

Gaertner SCIENTIFIC CORPORATION
1270 Wrightwood Ave.
Chicago 14, Illinois

Write in No. 171 on Reader Service Card

NEW!

SMALL!

DELCO POWER TRANSISTOR

Designed for use where space and weight are restricting factors

MAXIMUM RATINGS	2N1172
Collector Diode Voltage	40 volts
Emitter Diode Voltage	20 volts
Collector Current	1.5 Amperes
Junction Temperature	95°C
TYPICAL CHARACTERISTICS (25°C)	
Typ. Collector Diode Current I_{co} V_{cb}=40 volts	50μ
Current Gain (V_{ec}= −2 volts, I_c=100 Ma)	70
Current Gain (V_{ec}= −2 volts, I_c=½A)	30
Saturation Resistance	0.3 ohms
Cutoff Frequency (Common Emitter)	17 kc
Thermal Resistance	12° C/Watt

The 2N1172 is a medium power transistor offering dependable operation in a new range of applications where space and weight have been a problem.

It's a mighty mite with more punch in a smaller package. The 2N1172, excellent for output use or as a driver for a very high power transistor, has already proved especially effective in DC amplifiers, voltage regulators, and as a driver for a high power stage in servo or other amplifiers.

This PNP germanium transistor is housed in a modified version of the JEDEC 30 package with a diamond shaped base for improved thermal conduction. It dissipates up to 2 watts at a mounting base temperature of 70 degrees centigrade. Available now in volume production—write today for complete engineering data.

DELCO RADIO

Division of General Motors
Kokomo, Indiana

BRANCH OFFICES

Newark, New Jersey
1180 Raymond Boulevard
Tel: Mitchell 2-6165

Santa Monica, California
726 Santa Monica Boulevard
Tel: Exbrook 3-1465

Write in No. 172 on Reader Service Card at start of Product Preview Section

HAZELTINE relies on Photocircuits "Tuf-Plate" plated-thru holes

HEART OF ADVANCED AIRBORNE RADAR

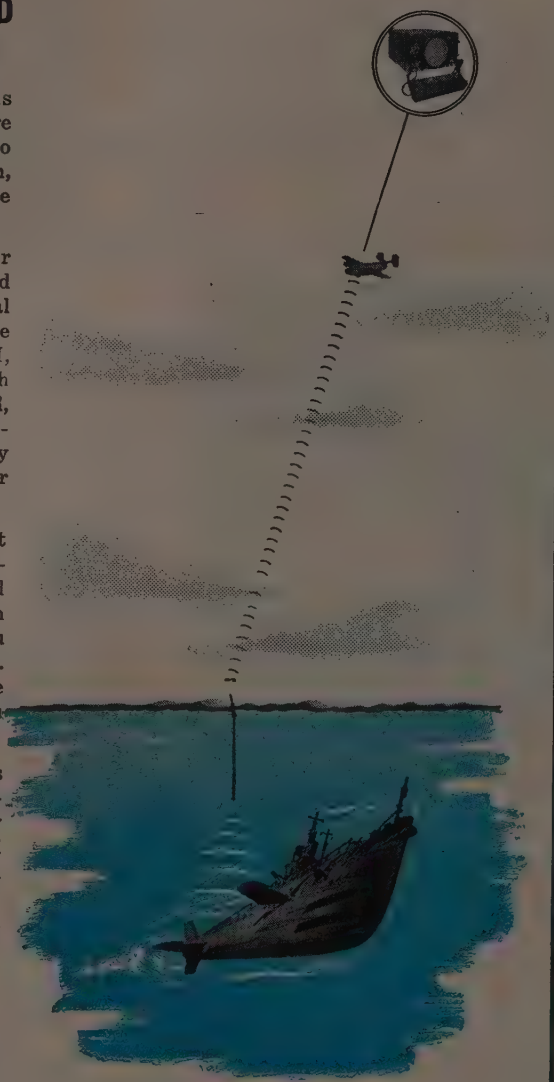
Strategic military decisions stem from reliable knowledge of an entire situation. To gather reliable information, our nation depends on airborne radar.

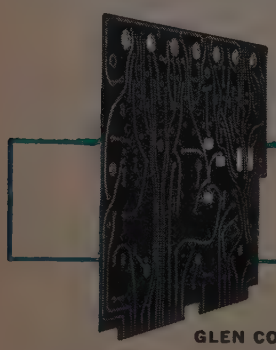
Hazeltine's universal radar indicator... the advanced AN/APA-125... displays signal data of many types: Submarine detection, AEW, IFF, AMTI, LAB, beacon and others. With this electronic plotting board, an operator can plot any tactical problem and accurately interpret the solution for evaluation and action.

For the compact, lightweight AN/APA-125, Hazeltine specifies space-saving, double-sided printed circuit boards with "TUF-PLATE" plated-thru holes by PHOTOCIRCUITS. Here is reliability never before possible in two-sided thru-circuitry.

"TUF-PLATE" reliability is guarded by rigid process engineering controls, developed by PHOTOCIRCUITS and unmatched in the printed wiring industry. Proper design, precision production and advanced quality control techniques assure consistently dependable performance... often at lower cost.

Get the detailed "TUF-PLATE" story today from PHOTOCIRCUITS... the largest and most experienced manufacturer in printed circuitry. Write our Engineering Department PS-3.





PC Photocircuits CORPORATION

GLEN COVE, NEW YORK

PHONES GLEN COVE 4-8000 FLUSHING 7-8100 | CABLE PHOCIRCO

Write in No. 173 on Reader Service Card at start of Product Preview Section

PRODUCT PREVIEW

TEMPERATURE CHAMBER tests small components

Economy, speed and simplicity of operation are featured in this temperature chamber designed for laboratory testing of small components. Maximum temperature available is —100 deg C and minimum, —60 deg C, and temperature can be changed from ambient to +70 or —40 deg C in under 15 min, says **The Fairey Aviation Co., Ltd., Dept. S/A, Heston, Middlesex, England.**

Heating of the stainless steel test chamber is electrical and refrigeration is obtained by means of solid carbon dioxide. The device's insulated cabinet contains an air circulating fan and duct, and a one-kw heating element. Chamber capacity is one cu ft.

Write in No. 239 on Reader Service Card

ALL-METAL AIRCRAFT carries five persons

The P.149-D is an all-metal aircraft that fits smoothly into training, liaison or executive operation, according to **Piaggio & Co., Dept. S/A, Genoa, Italy.** The cabin, which has a five-seat utility capacity, is equipped with a transparent hood that slides backward; for aerobatics, seating is limited to two persons.

The aircraft has a retractable tricycle landing gear. The power plant is a Lycoming GO-480-B engine rated at 260/270 hp. It permits a cruising speed, at 67 per cent power and 7500 ft, of 166 mph. The useful utility load is 1147 lb.

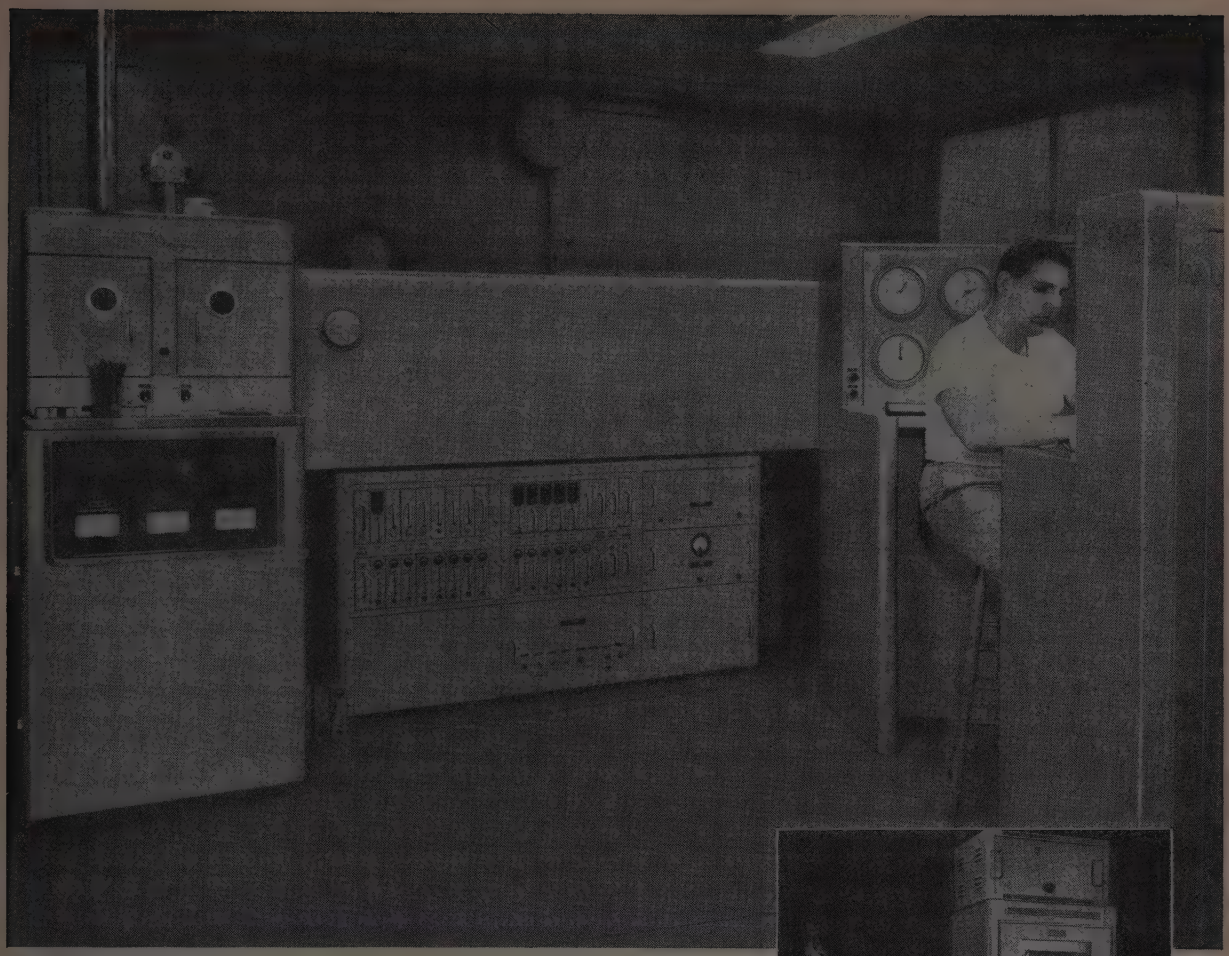
Write in No. 240 on Reader Service Card

ROCKET ENGINE is very small

The PR.23 is a self-contained liquid-propellant rocket engine that weighs about 32 lbs and has a minimum thrust of 500 lbs, says **Armstrong Siddeley Motors, Dept. S/A, Coventry, England.** Thrust is variable down to at least one-third full thrust, with slight reduction in specific impulse.

Use of the PR.23 is envisioned in altitude and velocity trimming applications in interplanetary and satellite vehicles, and long-range ballistic missiles. It is also suggested for high-altitude aircraft operation and for use as an aircraft booster engine. The small engine makes feasible fixed installations.

Write in No. 241 on Reader Service Card

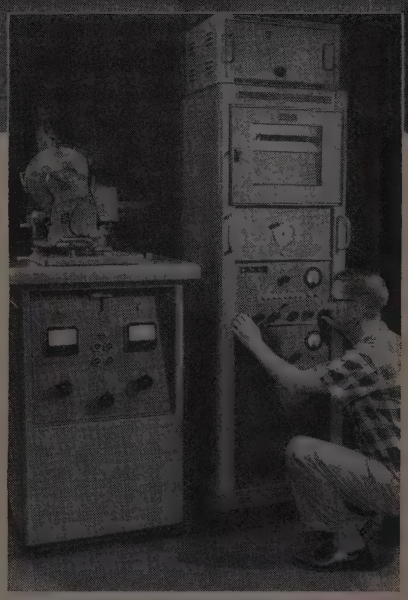


This late model emission-type spectrograph can give direct dial readings on as many as 20 different chemical elements in testing the composition of a special steel alloy.

Latest laboratory equipment speeds quality control at Standard

Installed in the Metallurgical Laboratory at Standard Steel Works are the latest scientific testing instruments for the most accurate and rapid testing of steels in all stages of production. Samples are delivered by pneumatic tube from melting furnace to laboratory in 90 seconds. Using the spectrograph pictured above, analyses can be determined in 1½ minutes, saving hours of time over older methods.

Standard's recently installed electric furnace and vacuum degassing equipment assure delivery on special alloy products in the shortest possible time. Standard's quality control procedure guarantees that your most exacting requirements will be met. Write Dept. 6-F for details.



There is a specific refraction index to fluorescent X-rays for each metal, and this latest, most interesting use of them is employed to determine the composition of certain stainless and other high-alloy steels.

Standard Steel Works Division

BALDWIN · LIMA · HAMILTON

BURNHAM, PENNSYLVANIA Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes

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Knowmanship *in action*—saving you dollars and days

Many associate contractors have the requirements to do a job for you—on paper. But it's not always so simple to locate one who can adapt himself to the problem at hand quickly and efficiently. When it comes to understanding *the project as a whole*, it takes an associate with experience—one who knows the ins and outs of the Weapons System Concept as a result of a thorough grounding in procedure from the beginning. Eclipse-Pioneer has that background.

A pioneer in aircraft sub-systems and components, we have been a recognized leader in this field for more than 40 years. Just as important, we have been a Weapons System associate-contractor since the very first contract was awarded to Convair for the B-58.

Our years of experience in sub-system research, development and production can go to work for you *before* you actually bid for the contract. Eclipse-Pioneer KNOWMANSHIP—our word for the critical combination of technical knowledge, experienced management and specialized craftsmanship that offers maximum value to a prime contractor—will fit into your team picture during the initial planning stages. We will apply our resources to help you win a major contract.

KNOWMANSHIP—such as we employed in the development and production of the autopilot for Douglas on the Navy A4D-2N and for other prime contractors on other major programs—can be a powerful ally in any system project.

Of course, even KNOWMANSHIP wouldn't do the job without the physical resources to back it up. We can call on the experience of more than 9,000 skilled people working in 1,104,000 square feet of plant space. These facilities are another major reason why Eclipse-Pioneer can be such a valuable partner to a prime contractor on advanced aircraft and missile development and production.

Our people are at your service whenever you have a project to discuss. A letter, wire or phone call will bring them to you with complete facts.

ECLIPSE-PIONEER

TETERBORO, N. J.
DIVISION of

Bendix
AVIATION CORPORATION

AUTOMATIC FLIGHT CONTROL • CENTRAL AIR DATA SYSTEMS • SPECIALIZED INSTRUMENTATION • NAVIGATION COMPUTERS AND DIRECTORS • STABLE PLATFORMS • INERTIAL GUIDANCE • RADAR ANTENNA STABILIZATION AND TRACKING SYSTEMS

Write in No. 175 on Reader Service Card at start of Product Preview Section

data preview

European Aerospace Progress

PRESSURE GAGES—Direct-reading and transmitting pressure gages for aircraft and test beds have been described in List A/16/1 by **Negretti & Zambra, Ltd., Dept. S/A, 122 Regent St., London W.1, England.** Transmitting types are available with ranges up to 2000 psi, and the direct-reading units can be obtained for pressures as high as 10,000 psi.

Write in No. 242 on Reader Service Card

SHIPBORNE RADARS—A discussion of naval radar equipment has been presented in Radar 59/499, an information sheet available from **Marconi's Wireless Telegraph Co., Ltd., Dept. S/A, Marconi House, Chelmsford, England.** The company's equipment meets the full operational requirements for small warships and is capable of being modified to suit anti-submarine, anti-aircraft and aircraft-direction roles.

Write in No. 243 on Reader Service Card

ENGINEERING FACILITIES — Three brochures have been prepared to provide a picture of the technical and manufacturing facilities of **D. Napier & Son, Ltd., Dept. S/A, Luton, Bedfordshire, England.** One of them covers these facilities as they pertain to aircraft engineering.

Write in No. 244 on Reader Service Card

FILTERS—Four-micron filtration is possible with the Microfilter aircraft and ground equipment filters, according to PHYD/192. A technical brochure available from **The Fairey Aviation Co., Ltd., Dept. S/A, Hayes, Middlesex, England.** These filters have been developed for use in pressure lines of hydraulic systems with ratings up to 4000 psi.

Write in No. 245 on Reader Service Card

CASTING FOUNDRY—Excellent illustrations of typical castings have been included in a survey of a precision casting foundry and its allied facilities by **D. Napier & Son, Ltd., Dept. S/A, Mansfield Rd., London W.3, England.** Aircraft turbine and compressor blades and components for rockets are among the products manufactured, according to Publication 261.

Write in No. 246 on Reader Service Card

ANALOG COMPUTER—A wide range of linear and non-linear mathematical functions can be provided by a modular-design electronic analog computer described in a folder available from **The Fairey Aviation Co., Ltd., Dept. S/A, Heston, Middlesex, England.** The basic arrangement will accept up to 96 operational dc amplifiers.

Write in No. 248 on Reader Service Card

SCATTER SYSTEMS—System design and equipment are among the factors briefly considered in a discussion of Tropospheric scatter systems, which is available in a booklet from **Marconi's Wireless Telegraph Co., Ltd., Dept. S/A, Marconi House, Chelmsford, Essex, England.** Transmitters, receivers, and antennas are the components covered.

Write in No. 249 on Reader Service Card

HIGH-THRUST JET—The high-thrust Olympus combines light weight and a low specific fuel consumption, according to a 20-page brochure prepared by **Bristol Aero-Engines, Ltd., Dept. S/A, Filton House, Bristol, England.** A Type Test rating of 17,000-lb has been chalked up for the jet bomber-destined engine, which is believed to have the highest thrust-weight ratio of any type-tested turbojet in this class.

Write in No. 250 on Reader Service Card

TURBOPROP—The Proteus 765, a turboprop that developes 4445 eph, has been described in a 24-page booklet by **Bristol Aero-Engines, Ltd., Dept. S/A, Filton House, Bristol, England.** Separate turbines are used to drive the compressor and propeller for optimum operation of each system.

Write in No. 251 on Reader Service Card

FIRE CONTROL—Two radar equipments for automatic control of anti-aircraft guns have been described in separate brochures available from **Compagnie Francaise Thomson-Houston, Dept. S/A, 173 Bd., Haussmann, Paris 8, France.** The TH. D. 1210 for heavy guns has a 64-km detection range, and the TH. D. 1225, for medium artillery, covers an area with a 30-km radius.

Write in No. 252 on Reader Service Card

HIGH POWER AMPLIFIER—Point-to-point communication transmitters for ionospheric forward-scatter transmission are using the Type HS 201 VHF amplifier, which has been described in Data Sheet Communications 59/265 by **Marconi's Wireless Telegraph Co., Ltd., Dept. S/A, Marconi House, Chelmsford, England.** The amplifier has a 20-kw output and operates over the 35 to 55-mc range.

Write in No. 253 on Reader Service Card

AIR-TO-AIR MISSILE—A brochure on the Fireflash, an air-to-air guided missile said to be the most efficient weapon of its kind anywhere, has been issued by **The Fairey Aviation Co., Ltd., Dept. S/A, Heston, Middlesex, England.** The device is a beam-riding missile that flies along a radar beam directed at the target by the attacking aircraft.

Write in No. 254 on Reader Service Card

COMMUNICATIONS—A large number of data sheets on various types of communication equipment has been prepared by **Compagnie Francaise Thomson-Houston, Dept. S/A, 173 Bd., Haussmann, Paris 8, France.** Included is information on ground-to-air UHF equipment radio links, amplifiers, transmitters, receivers, and generators.

Write in No. 255 on Reader Service Card

GAS GENERATOR—An eight-page brochure describing a gas generator suitable for use in the operation of the internal power supply equipment of almost every type of guided weapon has been issued by **Sir W. G. Armstrong Whitworth Aircraft, Ltd., Dept. S/A, Baginton, Coventry, England.** The TP-1 uses the mono-propellant iso-propyl nitrate for fuel.

Write in No. 256 on Reader Service Card

TINY TRANSFORMERS—A four-page technical brochure has been issued to describe a range of molded miniature pulse transformers and chocks made by **Murphy Radio, Ltd., Dept. S/A, Welwyn Garden City, Herts, England.** The one-in. components are suitable for most pulse circuits, and they can be wired into circuits in the same way as resistors.

Write in No. 257 on Reader Service Card

HEIGHT FINDER—An early-warning height-finder radar with an absolute height accuracy of ±1700 ft at 150 naut mi has been described in Radar 59/525, a data sheet available from **Marconi's Wireless Telegraph Co., Ltd., Dept. S/A, Marconi House, Chelmsford, England.** The three-mw Type S244 has a frequency range of 2700 to 2900 mc.

Write in No. 258 on Reader Service Card

TEMPERATURE CHAMBER—The laboratory testing of small components is possible with a one-cu ft-capacity temperature chamber described in a brochure available from **The Fairey Aviation Co., Ltd., Dept. S/A, Heston, Middlesex, England.** The economical device can achieve a temperature maximum of 100 deg C and a minimum of —60 deg C.

Write in No. 259 on Reader Service Card

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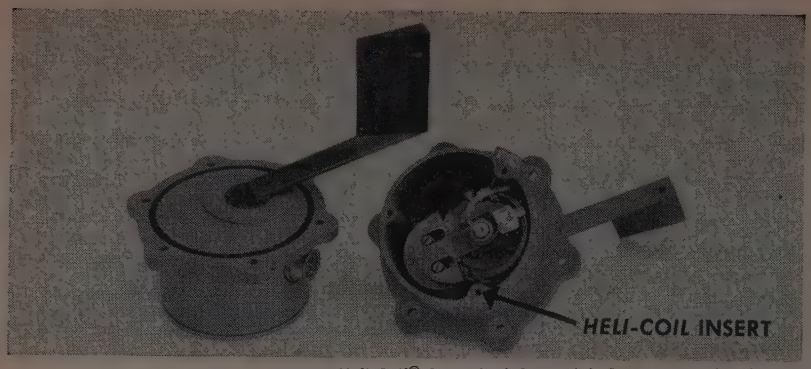


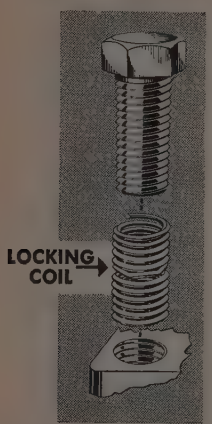
Heli-Coil® Screw-Lock Inserts* lock screws against impact and vibration and permanently protect critical tapped holes in this transducer assembly.

Critical Electronic Controls Get Internal-Locking, Protective Threads

with

HELI-COIL

Screw-Lock Inserts



Principle of *Heli-Coil* Screw-LOCK Insert. Locking center coil grips internally, holds screw firmly.

Electronic control devices for aircraft and missiles, like this angle of attack vane transducer made by U. S. SCIENCE CORPORATION, LOS ANGELES, CALIF., have to withstand severe vibration, impact, corrosion and temperature change. They must be made of light materials and still have strong threads — able to hold fasteners tightly and stand frequent assembly and disassembly.

U. S. SCIENCE insures rock-solid screw assemblies by protecting vital tapped holes with one-piece *internal-locking Heli-Coil* Screw-LOCK Inserts. These precision formed, stainless steel wire inserts eliminate thread wear, lock screws securely — without resort to clumsy, external lock nuts and lock wiring.

Simple Installation Procedure

U. S. SCIENCE finds it easy to install *Heli-Coil* Screw-LOCK Inserts. Drilled holes are tapped with a *Heli-Coil* tap and the Inserts wound in with a prewinder inserting tool. Conventional screws are used in assembling the unit.

Heli-Coil Screw-LOCK Inserts

- positively lock fasteners against loosening under impact and vibration
- prevent thread wear, stripping, corrosion, galling and seizing
- eliminate lock nuts, lock wiring, other supplementary locking devices
- permit repeated disassembly and reassembly
- can be used in standard proportion bosses without need for redesign
- save assembly time, space, weight and cost
- meet government specs for locking torque and vibration

*Patented

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION, 106 Shelter Rock Lane, Danbury, Connecticut
Send complete design data on *Heli-Coil* Screw-LOCK Inserts

NAME_____TITLE_____
FIRM_____
ADDRESS_____
CITY_____ZONE____STATE_____

IN CANADA: W. R. WATKINS CO., Ltd., 41 Kipling Ave., S., Toronto 18, Ont.

Write in No. 176 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

INSTRUMENTATION GEAR—Information on several types of equipment useful in instrumentation applications is available from **Sir W.G. Armstrong Whitworth Aircraft, Ltd., Dept. S/A, Baginton, Coventry, England.** The devices include a 70mm, multi-speed recording camera, a five-channel display unit, high-speed sampling switch with a maximum rotation of 200 rps, and a transistorized recording galvanometer.

Write in No. 260 on Reader Service Card

FLIGHT CONTROLS — The Hydrobooster, a powered flying control unit that has been fitted to some twenty different types of aircraft, is discussed in a leaflet available from **The Fairey Aviation Co., Ltd., Dept. S/A, Hayes, Middlesex, England.** Two representative types—single jack and tandem jack units—are described.

Write in No. 261 on Reader Service Card

STEEL CASTINGS—General information on investment moulded, high-tensile steel castings for aircraft structural and mechanical fittings has been provided in a brochure available from **The Fairey Aviation Co., Ltd., Dept. S/A, Hayes, Middlesex, England.** Advantages, specifications, and applications are considered.

Write in No. 262 on Reader Service Card

ATTACK BOMBER—A 12-page report on the Blackburn N.A.39 naval attack aircraft has been issued by **Blackburn & General Aircraft, Ltd., Dept. S/A, Brough, East Yorkshire, England.** The twin-jet aircraft designed for low-level attack, has its fuselage tail-cone split to form airbrakes.

Write in No. 263 on Reader Service Card

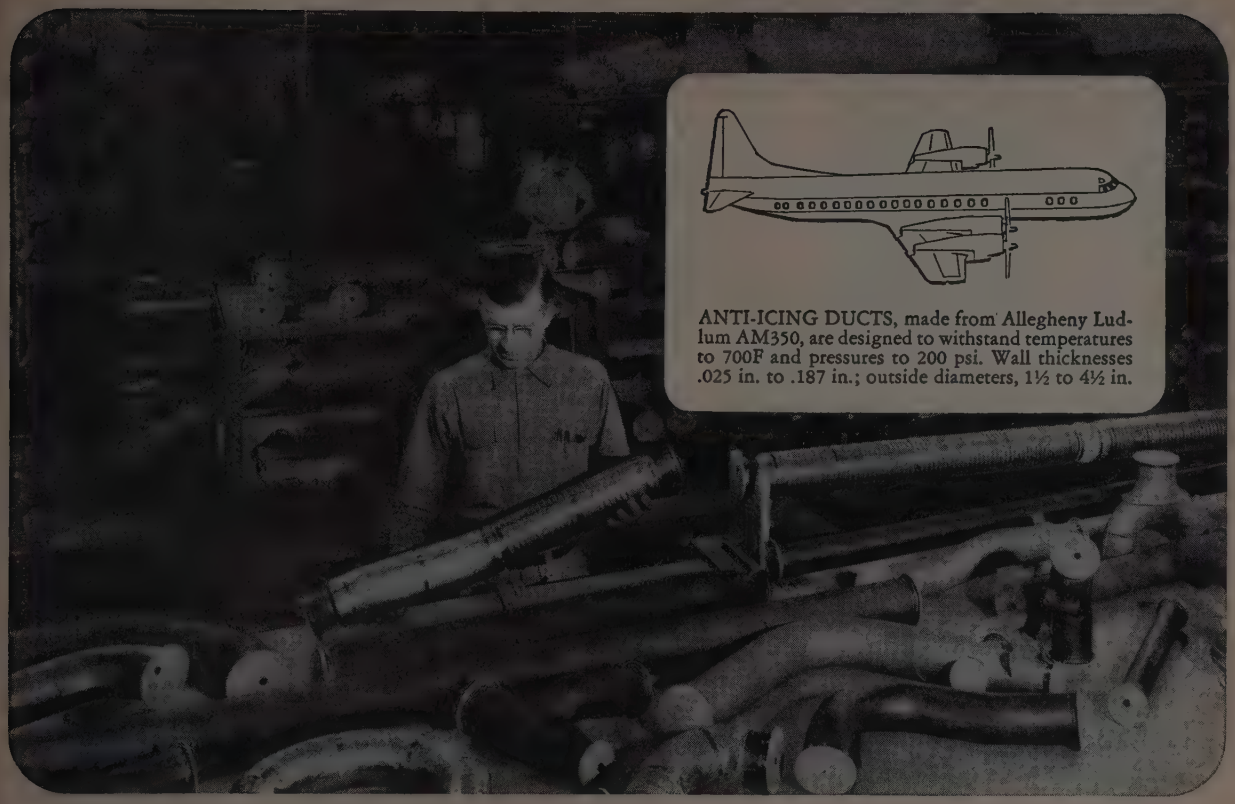
SCATTER AMPLIFIER—The Type HS 313 amplifier, which consists of a 10-kw water-and-air cooled klystron, is being used in tropospheric scatter links to provide reliable UHF communications over distances up to 250 mi in one hop, according to a data sheet, Communications 59/261, issued by **Marconi's Wireless Telegraph Co., Ltd., Dept. S/A, Marconi House, Chelmsford England.** Frequency ranges are 400 to 525 mc and 680 to 970 mc, or both.

Write in No. 264 on Reader Service Card

JET ENGINE—Performance and construction data on two Viper turbojet engines have been included in Brochure I.L./58/8/11 issued by **Armstrong Siddeley Motors, Ltd., Dept. S/A, Coventry, England.** The Viper ASV.8 is rated at 1750 lbs thrust, and the ASV.11 is rated at 2460 lbs. Viper engines have been used in trainers, missiles, target drones, and other applications.

Write in No. 265 on Reader Service Card

more on page 242



ANTI-ICING DUCTS, made from Allegheny Ludlum AM350, are designed to withstand temperatures to 700F and pressures to 200 psi. Wall thicknesses .025 in. to .187 in.; outside diameters, 1½ to 4½ in.

made from Allegheny Ludlum precipitation-hardening stainless:

Prop-jet's anti-icing ducts take high heat and pressure in stride

The anti-icing system of a new prop-jet airliner was designed to operate under high heat and pressure, yet the ducting had to be as light as possible. AM350 was specified. Both AM350 and AM355, Allegheny Ludlum's precipitation-hardening stainless steels, have strength/weight ratios at 600F five times greater than the usual aluminum aircraft alloy. In fact, AM350 and AM355 maintain high strength from room temperature up to 1000F.

These space age metals have other properties highly desirable: excellent corrosion resistance, ease of fabrication, low temperature heat treatment, good resistance to stress corrosion.

These features have been used to advantage in airframe structural members, airframe skins, pressure tanks, power plant components, high pressure ducting, nacelles and other missile and supersonic aircraft applications.

availability: AM350, introduced several years ago, is available commercially in sheet, strip, foil, small bars and wire. AM355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars and wire.

corrosion resistance: Compared to the more familiar stainless grades, AM350 and AM355 resist corrosion and oxidation better than the hardenable grades (chromium martensitic) and only slightly less than the 18 and 8's. They resist stress corrosion at much higher strength levels than do martensitic stainless grades.

simple heat treatment: High strength is developed by two methods. Both minimize oxidation and distortion problems. The usual is the Allegheny Ludlum-developed sub-zero cooling and tempering (SCT): minus 100F for 3 hrs plus 3 hrs at 850F. Alternate method is Double Aged (DA): 2 hrs at 1375F plus 2 hrs at 850F.

easy fabrication: AM350 and AM355 can be spun, drawn, formed, machined and welded using normal stainless procedures. In the hardened conditions, some forming may be done . . . 180 degree bend over a 3T radius pin. Also AM350 can be dimpled in the SCT condition to insure accurate fit-up.

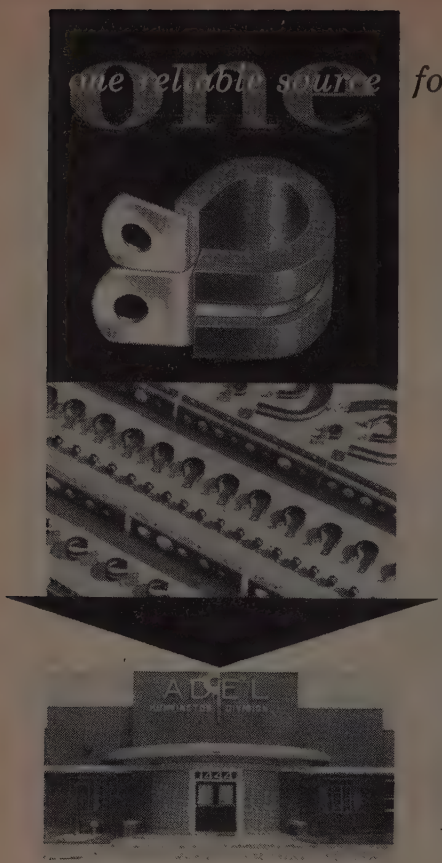
For further information, see your A-L sales engineer or write for the booklet "Engineering Properties, AM350 and AM355." ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*** Address Dept. AV-18.

WSW 7341

ALLEGHENY LUDLUM

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

Write in No. 177 on Reader Service Card at start of Product Review Section



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CLIP, BLOCK *and*

HARNESS STRAP

needs!

ADEL offers the widest variety of LINE SUPPORTS in the World . . . 19,000 different types and sizes for safe, vibration-free, positive support in all types of aircraft, missiles, rockets, ordnance, automotive and original equipment of all kinds.

SAFETY . . . FLEXIBILITY . . . DURABILITY . . . ECONOMY . . . SERVICE FITTED . . . SERVICE TESTED . . . SERVICE APPROVED

Illustrated are but a few of the World's most complete line of Line Supports that meet or exceed all applicable specifications and/or requirements. Whatever the application—STANDARDIZE ON ADEL—the leader in completeness of line, service and reliability.

Reliability

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A DIVISION OF GENERAL METALS CORPORATION

SPECIFICATIONS ARE AVAILABLE TO AIRCRAFT, MISSILE AND ORIGINAL EQUIPMENT MANUFACTURERS . . . WHAT ARE YOUR REQUIREMENTS?

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Dayton • Wichita • Dallas • Toronto

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ETALON
INGAGE
measures the exact BORE or blind hole size!
Reading: .0001"
Size 3/16" to 4"
Takes accurate measurements of blind holes. No masters or setting rings—measures directly—by .0001".
Automatic alignment, rectangular contact points guarantee extreme accuracy even when fully extended. Immediately detects out of round holes; with extensions measures holes up to 6 feet deep. Hardened contact points exert minimum pressure—will not damage fragile work.
Easy to read, deep graduations on a large diameter thimble. Dull chrome plated. Furnished in English or Metric graduations, individually or in sets.
WRITE FOR CATALOG on complete line of precision measuring instruments: VERNIER CALIPERS, MICROMETERS, DIAL INDICATORS.
ALINA
ALINA CORPORATION
122 East Second St.
Mineola, L. I., N. Y.

Write in No. 179 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

DE-ICER—A surface heater, which is constructed by means of spraying, can be used in industrial applications, as well as in the prevention of formation of ice on aircraft, according to Publication LTP.73, printed by **D. Napier & Son, Ltd., Dept. S/A, Acton, London W.3, England.** The spraymat electrical heater can maintain surface temperatures of over 100 deg C, and it is useful on both metallic and non-metallic materials.

Write in No. 266 on Reader Service Card

ENGINES—Three types of aircraft engines have been described in several brochures and pamphlets issued by **D. Napier & Son, Ltd., Dept. S/A, London W.3, England.** They are: the Eland gas turbine for both turboprop transports and helicopters; the Gazelle Helicopter free turbine; and the Scorpion liquid propellant rocket engine for high altitude interceptor aircraft.

Write in No. 267 on Reader Service Card

AUTOPILOT — A 32-page booklet thoroughly describing the SEP 2 automatic pilot has been published by **Smiths Aircraft Instruments, Ltd., Dept. S/A, Cricklewood, London, NW2, England.** The device controls aircraft attitude, altitude, and airspeed, and it provides automatic guidance under localizer, glide path and omni range control.

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HELICOPTERS—Two gas turbine helicopters, the LE SO.1221 Djinn, and the LE SE.3130 Alouette II, have been described in a packet issued by **Sud-Aviation, Dept. S/A, 37, Blvd. De Montmorency, Paris 16, France.** In addition, specification and performance data have been covered more extensively in separate brochures. The Alouette II is a five-passenger, 360-hp aircraft, and the Djinn, a general-utility two-seater, has a maximum speed of 81 mph.

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UTILITY AIRCRAFT—A take-off distance, to 50 ft, of 230 yds is claimed for the Pioneer, a single-engine, high-wing monoplane described in a 24-page brochure issued by **Scottish Aviation, Dept. S/A, Prestwick Airport, Ayrshire, Scotland.** The all-metal utility aircraft seats five and can be used in a variety of special applications, such as aerial photography, crop dusting, ambulance operations, and dual-control training.

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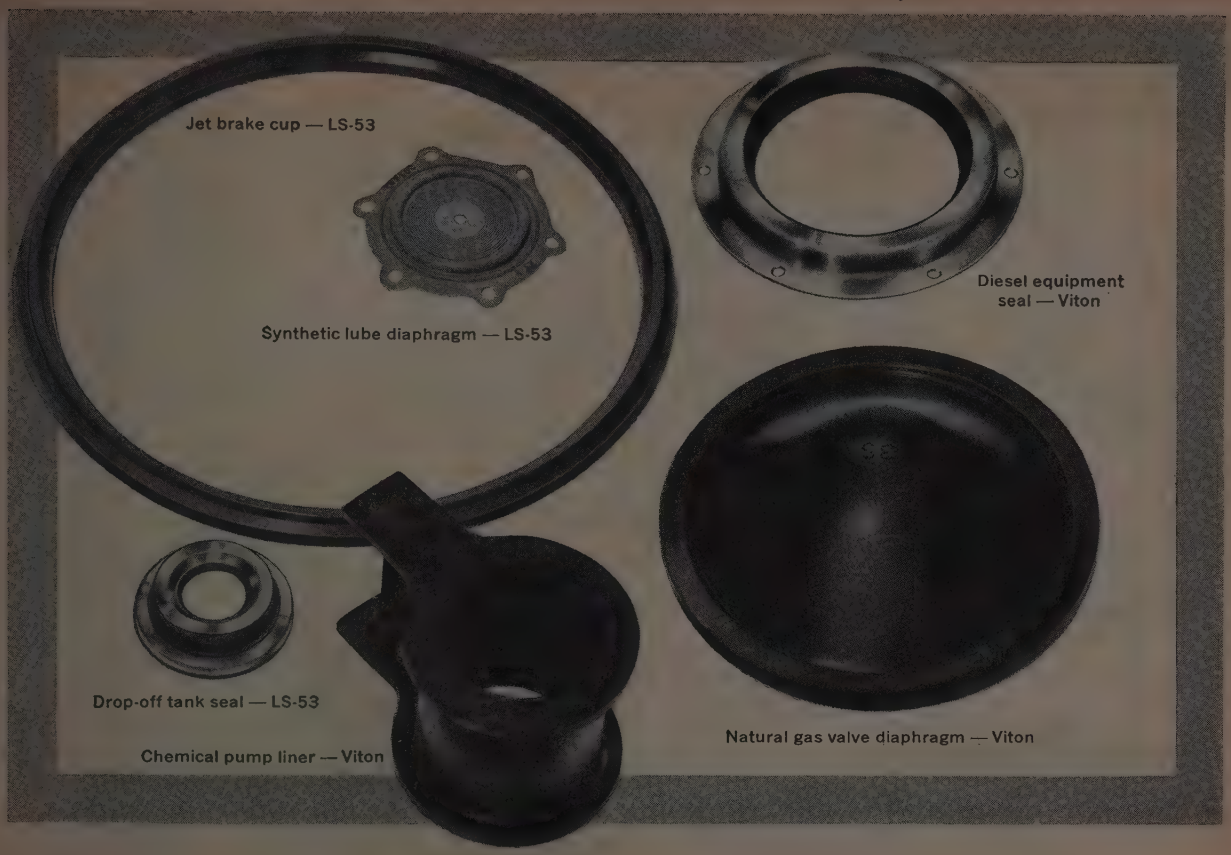
more on page 244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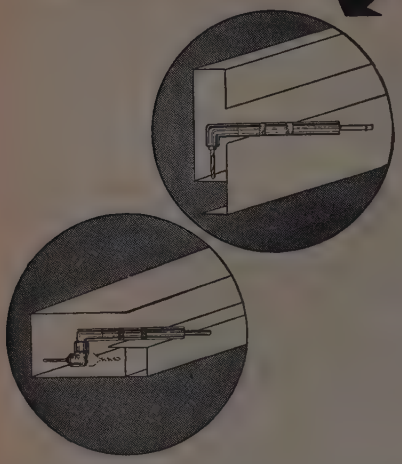

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DATA PREVIEW

GAS TURBINES—An informative brochure presenting major performance specifications on a variety of gas turbine engines has been prepared by **Blackburn & General Aircraft, Ltd., Dept. S/A, Brough, E. Yorks, England.** High performance, excellent design for maintenance, and parts interchangeability are featured.

Write in No. 271 on Reader Service Card

JET TRANSPORT—A packet that gives complete information on the SE-210 Caravelle DV 699 twin jet transport has been prepared by **Sud-Aviation, Dept. S/A, 37, Blvd. De Montmorency, Paris 16, France.** Data on the 80-passenger aircraft includes specifications, performance details, and a review of the aircraft's creation.

Write in No. 272 on Reader Service Card

TANDEM ROTORS—B-TRH-1-1 is a brochure that points up the merits of turbine-powered twin-rotor helicopters made by **Bristol Aircraft, Ltd., Dept. S/A, Filton House, Bristol, England.** The twin-engine Type 192 has a maximum speed of 120 kt, and its power characteristics permit it to cruise at top speed.

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VOLTAGE REGULATOR—A regulated 19-V dc supply for tube heater circuits in aircraft radio and electronic equipment has been described in Data Sheet VR61B by **Murphy Radio, Ltd., Dept. S/A, Welwyn Garden City, Herts., England.** Maximum current rating is 25 amps, and input supply limits are 22 to 28.5 V dc.

Write in No. 274 on Reader Service Card

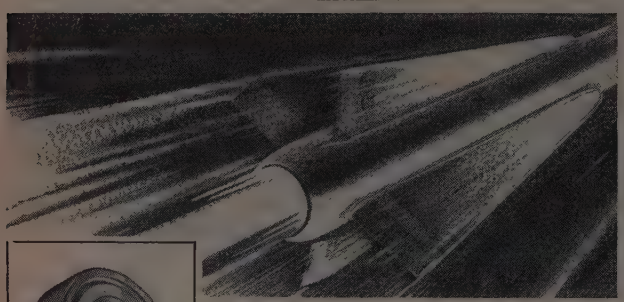
ENGINE CONTROL—Systems for the control of turbine engines have been considered in several booklets and a four-page brochure issued by **Ultra Electric, Ltd., Dept. S/A, Western Ave., London W.3, England.** Equipments covered include turbine speed and jet pipe temperature control amplifiers, throttle controls, and synchronizing control.

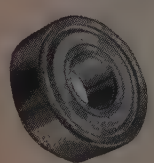
Write in No. 275 on Reader Service Card

VALVES—Hydraulic, pneumatic and temperature-controlled valves for aircraft applications have been described in data sheets included in a catalog issued by **Western Mfg. (Reading), Ltd., Dept. S/A, The Aerodrome, Reading, Berkshire, England.** Pressure relief, shut-off and directional control valves are among the types considered.

Write in No. 276 on Reader Service Card

more on page 246





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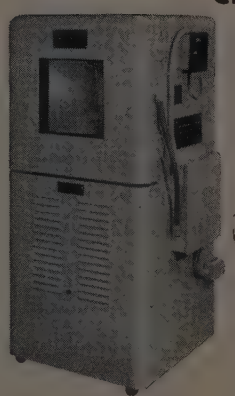

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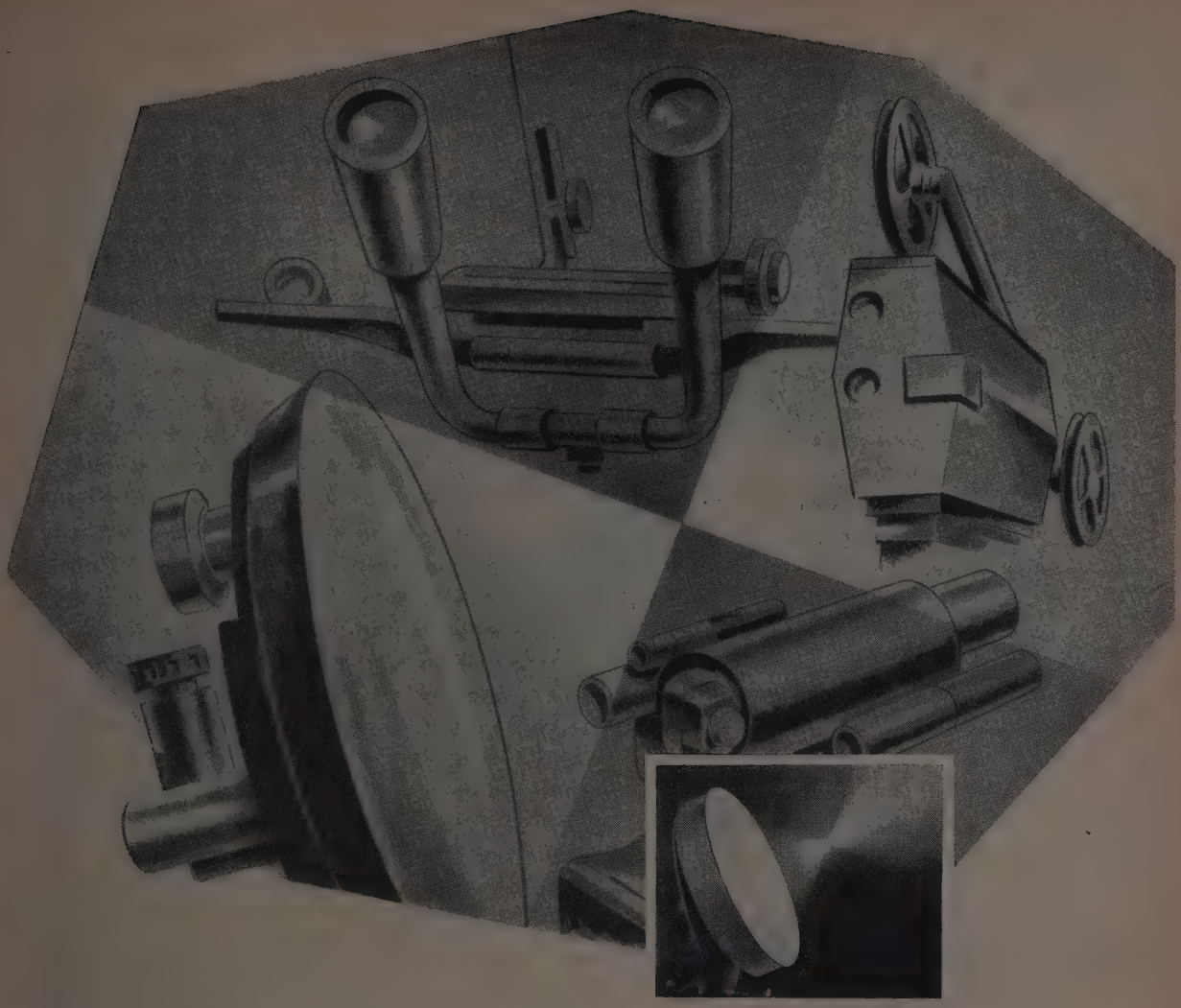

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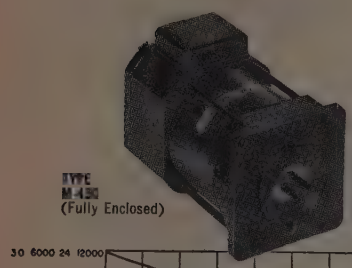
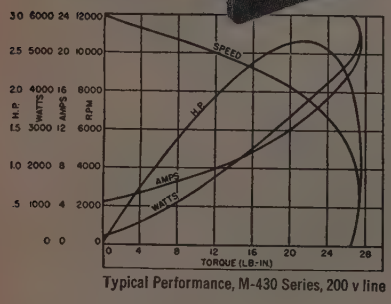
new high-performance motors from AIRBORNE

M-430, 440 Series typify capabilities in meeting special design requirements

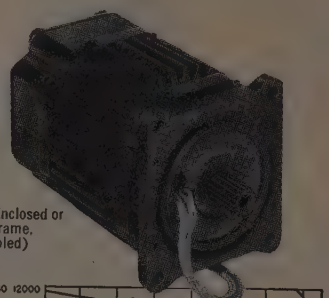
These 400-cycle, 3-phase, 115/200 v a-c motors were developed originally as components of Airborne large special actuators for aircraft/missile applications. Because of their useful performance characteristics, we now offer them separately—both as additions to our line of special motors and as examples of Airborne capabilities in their particular class of application.



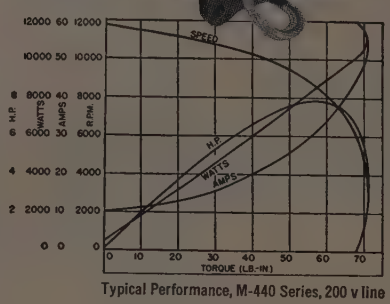
TYPE M-430 (Fully Enclosed)



Typical Performance, M-430 Series, 200 v line



TYPE M-440 (Fully Enclosed or Open Frame, Fan Cooled)



Typical Performance, M-440 Series, 200 v line

M-430 Series, 3-in. frame

Intermittent duty ratings to 1.8 hp; continuous ratings to 1.0 hp. Available with magnetic brake which will stop motors in 22 rev. from no-load speed and provide 30 in.-lb. holding torque. Model shown is a 7.5 lb. brake-equipped motor rated 1.5 hp at 10,000 rpm under a duty cycle of 0.5 min. on, 9 min. off.

M-440 Series, 4-in. frame

Intermittent duty ratings to 5 hp; continuous ratings to 2.5 hp (neither of these are absolute ceilings). Optional brake provides holding torque of 140 in.-lb., stops motors in 20-40 rev. from no-load speed. Model shown weighs 13.2 lb. with brake, is rated 4.0 hp at 10,000 rpm—1 min. on, 1 min. off.

Whatever your requirements in large special high-performance motors—a-c or d-c—it will pay you to check with Airborne. Most likely we can furnish a motor of minimum weight and bulk that will meet exactly your specifications. Write or phone any of our offices.

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DATA PREVIEW

OXYGEN EQUIPMENT—Two publications on aircraft oxygen equipment are available from **Normalair, Ltd., Dept. S/A, Yeovil, England.** Catalog N.3 is a six-page report on equipment such as liquid oxygen converters and regulators, and Leaflet XN 33 contains two pages of information on a 100-psig, 3½-1 converter.

Write in No. 277 on Reader Service Card

REINFORCED PLASTICS—The advantages of preimpregnated reinforced plastics have been briefly discussed in PM804, a data sheet available from **Aeroplastics, Ltd., Dept. S/A, Hillington, Glasgow, S.W.2, Scotland.** Greater ease of handling, longer shelf life and other benefits are achieved for all normal types of laminating resins, and reinforcements based on glass, Nylon, Orlon, and Terylene.

Write in No. 278 on Reader Service Card

JET ENGINE—Leaflet GT 60/8/58 on the Sapphire, a single-shaft turbojet available in several versions, has been issued by **Armstrong Siddeley Motors, Ltd., Dept. S/A, Coventry, England.** The engine has a 13-stage axial flow compressor and, in a reheat version, is designed for 12,300 lbs thrust.

Write in No. 279 on Reader Service Card

COMPONENTS—Terminals, plugs and sockets, circuit protection devices and antenna arrays are among the instrumentation components considered in the General Catalog and a supplement prepared by **Belling & Lee, Ltd., Dept. S/A, Great Cambridge Rd., Enfield, Middx., England.** The catalog's sections have been color coded according to components for easier reference.

Write in No. 280 on Reader Service Card

ROCKETS—Three booklets on rocket engines for aircraft have been published by **Société d'Etude de la Propulsion par Reaction, Dept. S/A, 37 Rue des Acacias, Paris 17, France.** The SEPR 481 and SEPR 66, both self-contained types, have been emphasized in separate booklets; both dependent and self-contained types are covered by the third.

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SHADED-POLE MOTORS—The Series EM 28 motors which are two-pole, self-starting asynchronous motors particularly suitable for driving fans, heater equipment, and small pumps, have been described in Type Sheet **134-42-1 E by Standard Elektrik Lorenz AG, Dept. S/A, Hellmuth-Hirth-Strasse 42, Stuttgart, Germany.** The 2$^{9}/_{32}$-in. motor features a high starting torque, and there is no radio interference.

Write in No. 282 on Reader Service Card

SURVIVAL—A technical catalog that offers a comprehensive survey of life saving and survival equipment for aircraft has been prepared by **P. Frankenstein & Sons (Manchester), Ltd., Dept. S/A, Newton Heath, Manchester 10, England.** Information has been compiled on high altitude equipment such as anti-G suits, life jackets, anti-exposure suits, flying suits, and dinghies.

Write in No. 283 on Reader Service Card

MOTORS—Publication 301/1, a file of data sheets for a variety of high-efficiency, low-weight motors, has been complied by **Evershed & Vignoles, Ltd., Dept. S/A, Acton Lane Works, Chiswick, London, W4, England.** The FHP Series of motors include servo types, ac and dc generators, constant speed units, special purpose ac motors, and others.

Write in No. 284 on Reader Service Card

INTERCEPTOR—Data on development and general characteristics have been included in a description of the light interceptor SO-9050 Trident II aircraft by **Sud Aviation, Dept. S/A, 37, Boulevard de Montmorency, Paris 16, France.** The aircraft can be operated from small, roughly prepared airstrips, and it has a power plant consisting of a rocket engine and two light turbojets.

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TAPE REPRODUCER—A continuous playing time of two hrs is possible with an airborne magnetic tape reproducer described in an information sheet available from **Murphy Radio, Ltd., Dept. S/A, Welwyn Garden City, Herts., England.** The Type MR310/T accommodates standard 7½-in. reels of tape and uses automatic reversal of the tape to achieve continuous play.

Write in No. 286 on Reader Service Card

SMALL ROCKET ENGINE—Advantages of the PR.23, a very small, variable thrust liquid propellant rocket engine useful in missile and aircraft applications, are discussed in a four-page brochure published by **Armstrong Siddeley Motors Ltd., Dept. S/A, Coventry, England.** The 32-lb device has a minimum 500-lb thrust.

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TACTICAL AIRCRAFT—Performance data and operational applications are considered in a six-page description of the Baroudeur single seater aircraft designed for light tactical support by **Sud Aviation, Dept. S/A, 37, Boulevard de Montmorency, Paris 16, France.** The jet can be operated from small emergency airfields, and a three-skid system is used in place of conventional landing gear.

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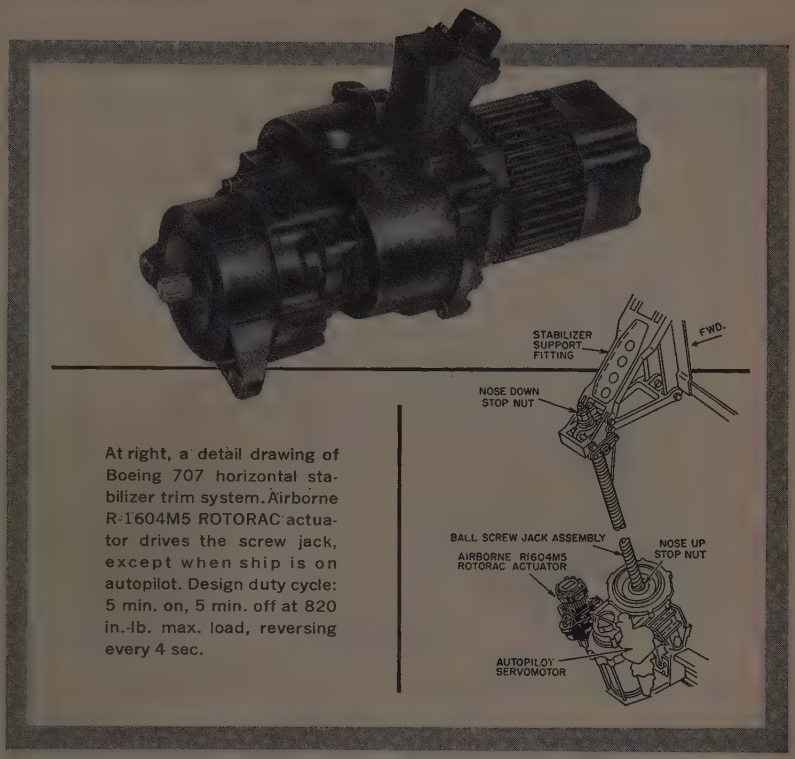

At right, a detail drawing of Boeing 707 horizontal stabilizer trim system. Airborne R-1604M5 ROTORAC actuator drives the screw jack, except when ship is on autopilot. Design duty cycle: 5 min. on, 5 min. off at 820 in.-lb. max. load, reversing every 4 sec.

Because of its function—operation of a primary flight control on Boeing's 707 — this Airborne ROTORAC large special actuator must provide the utmost reliability under almost continuous off-on-reverse type operation. And its response must be quick, even though maximum torque and acceleration are limited by specification — to avoid inadvertent structural overloads.

To control torque, Airborne developed a special friction clutch which limits output to 1500 in.-lb. maximum and yet will transmit 1200 in.-lb. under any condition. Controlled accelerations were achieved by balancing the inertia characteristics of all rotating parts and of the external load against the carefully tailored performances of the motor and servo clutches. Result: smooth acceleration from 0 to 180 rpm in 0.4 second and shock-free reversal in 1.0 second, both at full load.

Airborne offers you engineering of this caliber to meet needs for almost any special rotary or linear electromechanical actuator—large or small. And where requirements are not unique, we provide a line of modular-type actuators, developed by Airborne to simplify design and specification. Just give us the facts on your application and we will be happy to make a proposal. Contact any of our offices for further information.

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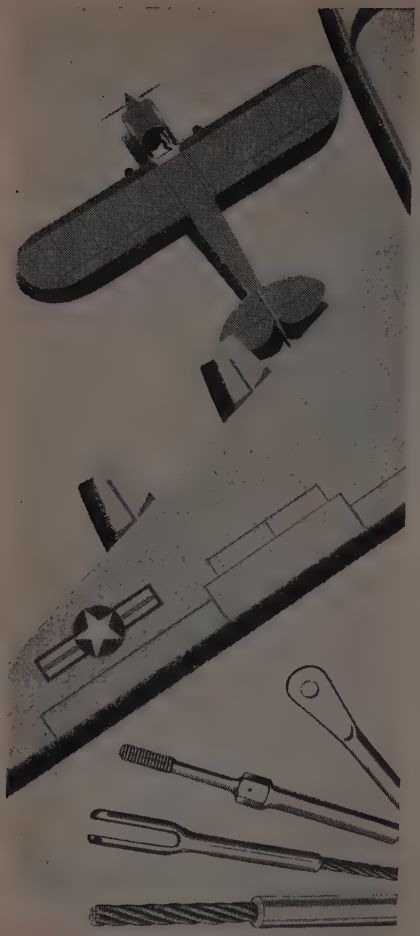

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DATA PREVIEW

AIR FREIGHTER—An illustrated brochure on a cargo transport with a payload capability of 22 tons has been prepared by **Blackburn & General Aircraft, Ltd., Dept. S/A, Brough, E. Yorks, England.** The four-engine Universal is also adaptable for passenger traffic, and it will carry up to 160 persons in short haul operations.

Write in No. 289 on Reader Service Card

WING & ROTOR—The Rotodyne, an all-weather transport aircraft that combines helicopter and fixed-wing performance, is the subject of a technical paper issued by **The Fairey Aviation Co., Ltd., Dept. S/A, Hayes, Middlesex, England.** The 50-page pamphlet outlines the design philosophy behind the aircraft and fully discusses structure, flying procedures, power plants, and other relevant factors.

Write in No. 290 on Reader Service Card

MULTI-CHANNEL VHF—Current requirements for airborne radio installations can be met economically and efficiently with the MR80 and MR100 VHF communications systems, according to a brochure prepared by **Murphy Radio, Ltd., Dept. S/A, Welwyn Garden City, Herts, England.** The MR80 provides 23 channels and the MR100, 36 channels. Both types are available with intercommunications facilities.

Write in No. 291 on Reader Service Card

DATA HANDLING—PD 583, an information sheet, describes a comprehensive system for air traffic data handling devised by **Marconi's Wireless Telegraph Co., Ltd., Dept. S/A, Marconi House, Chelmsford, England.** The system, said to be an entirely new approach to the problem, combines flight plan and radar-obtained information into a concise presentation for the controller.

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DOPPLER NAVIGATION—Three Doppler navigation systems, the AD-2300, AD2100, and AD2000, have been described in information sheets Aeronautical 59/3, 59/5 and 59/7, respectively, by **Marconi's Wireless Telegraph Co., Ltd., Dept. S/A, Marconi House, Chelmsford, England.** In addition, Brochures Ref.SP.64 and Ref.SP.71 provide further data on the AD-2300, the airborne system designed especially for commercial airline use.

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more on page 250

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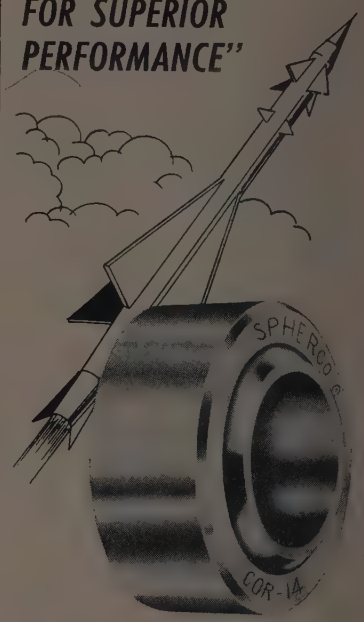

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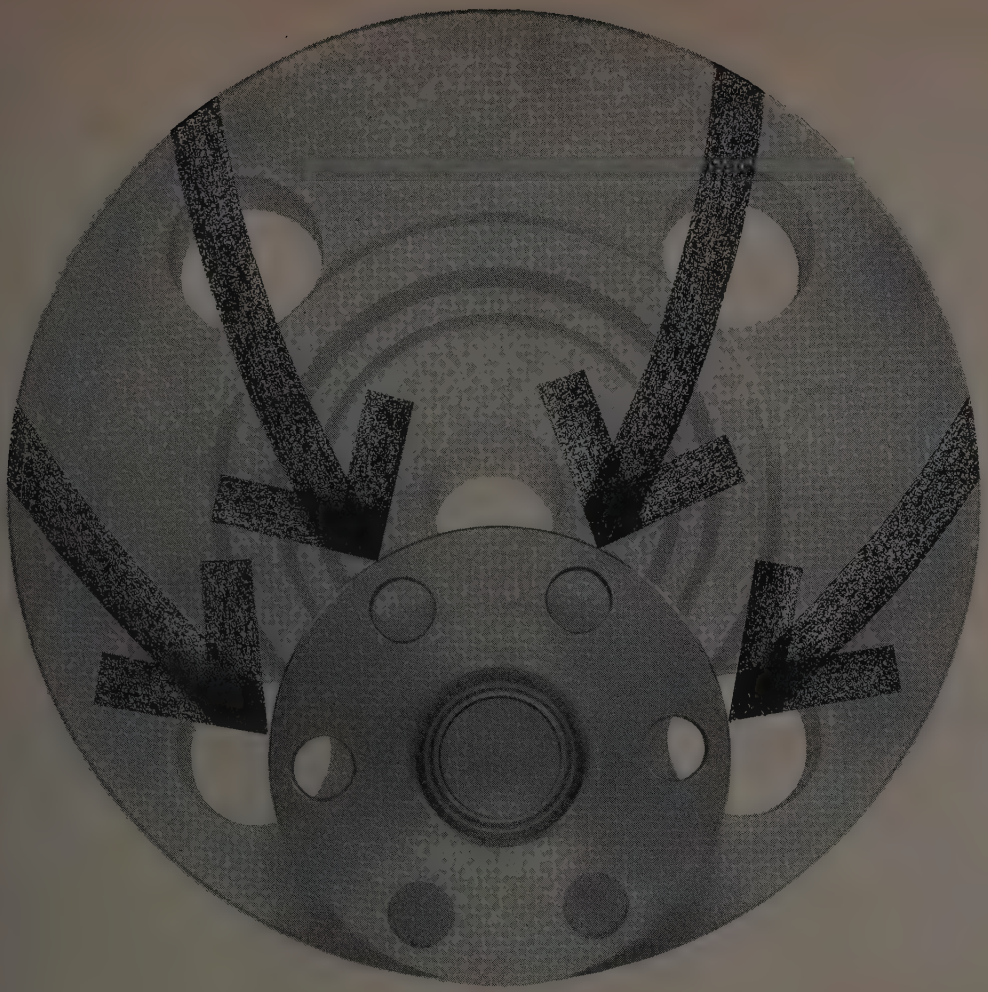

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INTERFERENCE TRACER—MR504, an information sheet on a lightweight, portable interference-tracing receiver that locates CW or impluse interference has been issued by **Murphy Radio, Ltd., Dept. S/A, Welwyn Garden City, Herts., England.** The device operates from dry batteries and provides a relative indication of signal level, either visual or aural.

Write in No. 294 on Reader Service Card

TURBINE ENGINES—Several data sheets presenting performance and applications information on various turbine engines are available from **Société Turboméca, Dept. S/A, Bordes (Basses-Pyrénées), France.** Both helicopter and fixed-wing types are discussed, and shaft turbines, turboprops and gas generators are among them.

Write in No. 295 on Reader Service Card

LIGHT JET—Information on the fighter and trainer versions of the Gnat light aircraft is available from **Folland Aircraft, Ltd., Dept. S/A, Hamble, Southampton, England.** The trainer, which weighs 7430 lbs, has two Bristol Orpheus turbojets, and it can attain a ceiling of over 45,000 ft.

Write in No. 296 on Reader Service Card

RAMJET—A four-page booklet entitled "Ram Jet Development" has been released by **D. Napier & Son, Ltd., Dept. S/A, Acton, London W.3, England.** Highlights of a ramjet test vehicle program are presented.

Write in No. 297 on Reader Service Card

ROCKET ENGINES—Publication LTP. 32 is a booklet on the development of rocket engines by **D. Napier & Son, Ltd., Dept. S/A, Acton, London W.3, England.** Such engines have been designed for both missiles and aircraft, and they include the Scorpion, which is capable of repeated start and stop sequences at any altitude.

Write in No. 298 on Reader Service Card

METAL WORKING—Cold working techniques for producing jet engine components such as inlet guide vanes and stator blades are briefly discussed in a brochure by **Wilmot Breeden, Ltd., Dept. S/A, Goodman St., Birmingham, 1, England.** Other applications include the manufacture of cones and Venturis, and pistons.

Write in No. 299 on Reader Service Card

FACILITIES & PRODUCTS—Research and manufacturing facilities, and products made for the aircraft and other industries are the subjects of a 16-page booklet issued by **Western Mfg. (Reading), Ltd., Dept. S/A, The Aerodrome, Reading, Berkshire, England.** Also available is a leaflet which stresses aircraft products, such as small motors, valves, airframe fittings, and airframe structures.

Write in No. 300 on Reader Service Card

Check Employment Inquiry Form Page 153

Fellow Engineers and Scientists:

My company has asked me to tell you of the unusual opportunities in operations research at System Development Corporation. These range from positions for engineers and scientists who would like to develop their skills working in a team under an experienced leader to opportunities for those who are looking for positions of leadership. I hope that the following account of our work will lead you to inquire for further information.

Briefly, SDC's business is automated decision-making systems. More fully, we develop large scale, computer-based information processing systems in which the computer is used as an on-line, centralized control element for a system operating in real-time. At this stage of the art these systems are semi-automatic, the man-machine type in which man shares the repetitive control function with the computer. Our work is concept-oriented, rather than hardware-oriented, and deals with problems of over-all system design, data processing development, and man-machine system training.

The most fully developed large-scale semi-automatic system is the SAGE (Semi-Automatic Ground Environment) Air Defense System. We have a major responsibility in the development of SAGE. Our experience and unique team skills have led to diversification of our activities; we now have important contracts for other major military and government systems vital to our country. The demand for our services is reflected in our growth from 70 to more than 2,700 employees since 1955, and the intriguing possibilities of automated decision-making are only beginning to be realized.

In this brief message, I can only suggest the variety of operations research problems at SDC. Perhaps the most important point is that this variety is limited only by the imagination and initiative of our scientists.

Some examples of areas of work are: (1) allocation of decision-making functions between man and machine for optimal system performance; (2) measures of system capacity and system performance; (3) exploration and evaluation of design changes by operational gaming; (4) quality control and testing of operational computer programs; (5) allocation of computer capacity among several system functions; (6) scheduling and costing of production of operational computer programs; (7) optimal assignment of mixed weapons to targets.

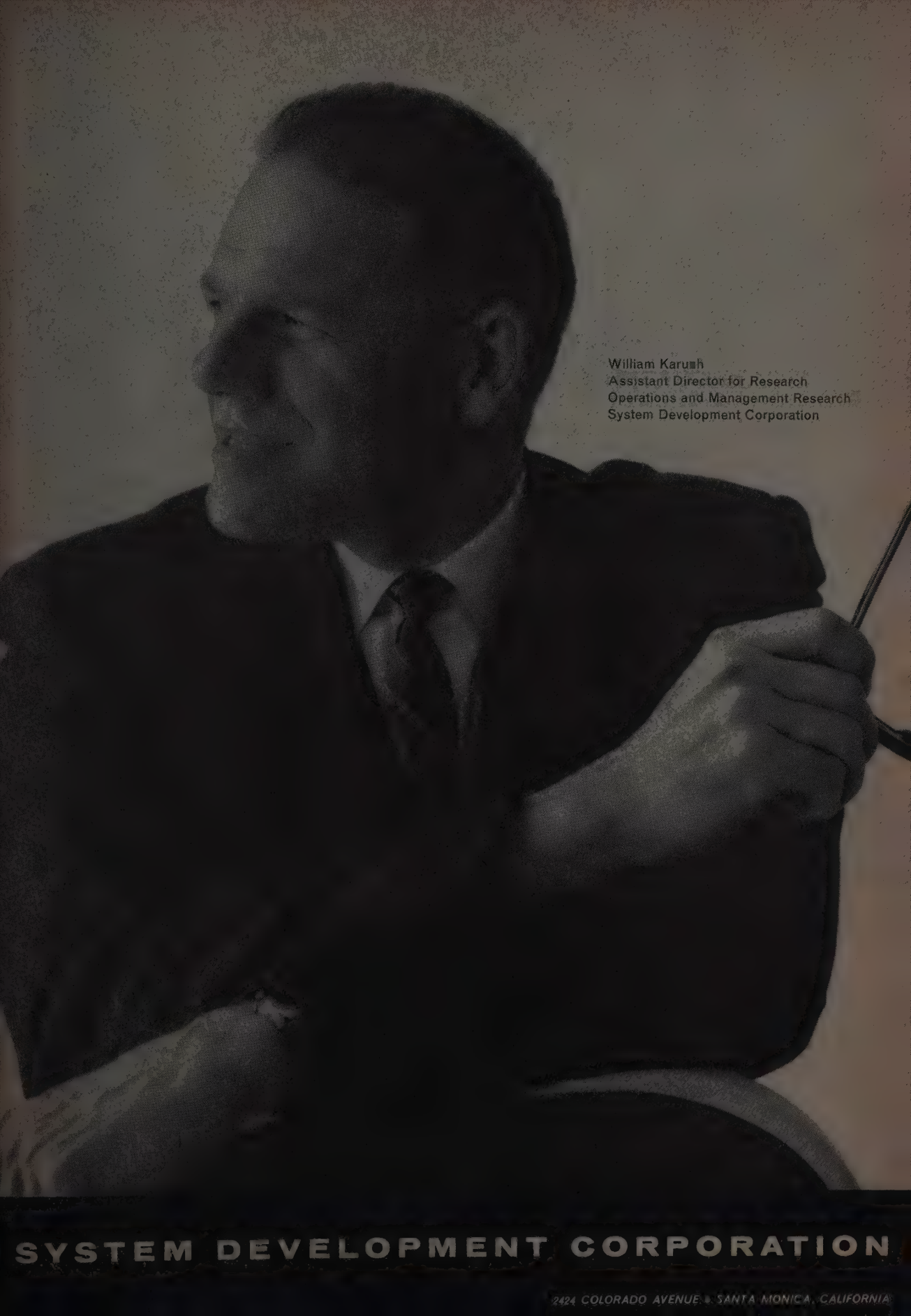
SDC recognizes the importance of a well planned research program for the vitality and future of the company, and we are carefully organized to carry out such a program. The following are some areas our operations research people are involved in: (1) simulation and operational gaming techniques in problems of control systems; (2) information retrieval and theory of information processing; (3) medical data processing; (4) universal language for computer programming; (5) logistics. We have unusual facilities for research at SDC—these include one of the largest computer facilities in the world and outstanding simulation laboratories.

We have given considerable thought to organizing the activities at SDC to provide for professional development and self-expression. Operations research professionals are carefully assigned so that their individual talents are matched with company needs. These assignments are reviewed regularly to make sure that developing talents are directed into new company opportunities. We regard the publication of research articles and participation in professional societies as activities important to the company. We encourage new ideas and provide the time and means to explore them.

SDC is one of the leaders in a field which will have a remarkable technological and scientific development. It is a new and vigorous company with a bright future. I encourage you to join us.

Please write Mr. R. W. Frost at the address below if you wish to pursue this invitation.

William Lonsdale



SYSTEM DEVELOPMENT CORPORATION

2424 COLORADO AVENUE • SANTA MONICA, CALIFORNIA

Mission: **MAN IN SPACE**

Filter Application: **PROTECT HYDRAULIC CONTROLS**

Filter: **PUROLATOR**

A malfunction in the lines of the hydraulic and pneumatic controls of the X-15 could send it off its programmed trajectory . . . alter the angle of re-entry . . . cause deviation from the ballistic arc.

Purolator filters are on the X-15 to protect the control systems. Three new filtering applications were worked out for North American Aviation, designers and builders of the X-15, by Purolator engineers to meet the space-age requirements of the manned missile.

Filters for crucial aircraft and missile requirements are a specialty at Purolator . . . and every application is considered as crucial as those on the X-15. Draw on Purolator's experience to help you handle your filtration requirements. A phone call or a descriptive letter, with plans or blueprints, will receive prompt attention.

Filtration For Every Known Fluid

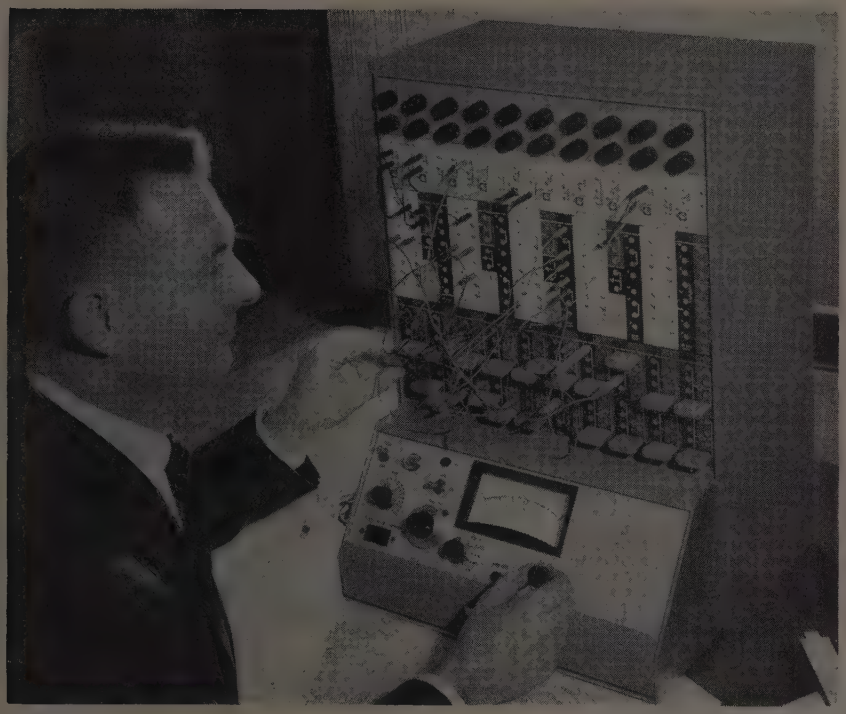
PUROLATOR

PRODUCTS, INC.

Rahway, New Jersey and Toronto, Ontario, Canada

Write in No. 190 on Reader Service Card at start of Product Preview Section

space/aeronautics **product of the month**



ANALOG COMPUTER is completely transistorized

Feature Product Award

JUNE 1959

Electronics Associates, Inc., Long Branch, N. J., has developed a low-cost analog computer that can perform 95 per cent of the routine mathematical operations an engineer makes in normal design calculations. The Pace TR-10 is 15 in. wide, 17 in. deep, and 24 in. high, and weighs only 80 lb without accessories. It is completely transistorized, and is accurate to 0.1 per cent. It occupies little more desk top area than a standard electric typewriter.

Typical areas of application for the TR-10 in the areospace field are guidance, control, and propulsive systems, electronic circuity, radar detection and ranging, and data acquisition. The computer makes analog computation easily accessible for every engineer and lets him obtain first-look solutions, especially on dynamics problems, in a fraction of the time they normally take. The price starts from just under $4000 and includes 10 operational amplifiers.

Write in No. 191 on Reader Service Card

This award is made in recognition of outstanding service performed through the development and manufacture of a product contributing to the advancement of the aerospace industry.

Randolph Hawthorne
Editor

product preview

FLEXIBLE HOSE is heat-resistant

A flexible hose of Du Pont Viton synthetic rubber that lasts almost indefinitely at 350 deg F and also resists chemical attack is being made by **H. K. Porter Co., Inc., Dept. S/A, Tacony and Comly Sts., Philadelphia, Pa.** It can be used at temperatures up to 600 deg F for short periods.

The hose may be used with jet fuels, highly aromatic mixtures, and petroleum lubricants. It resists penetration by tetraethyl lead compounds and also shows exceptional resistance to such solvents as carbon tetrachloride, toluene, and xylene, as well as to concentrated acids and bases. A Dacron jacket contributes to high strength and resistance to abrasion, and minimum burst strength is 600 psi. The hose is very flexible, does not collapse when bent around corners, and is not subject to cold flow. It is available in one- to four-in. id sizes.

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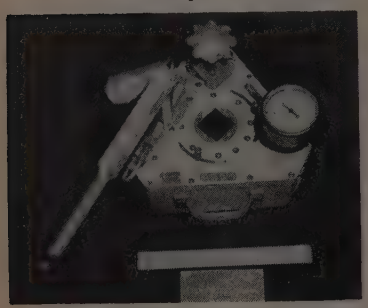
TORQUE WRENCH simple to operate

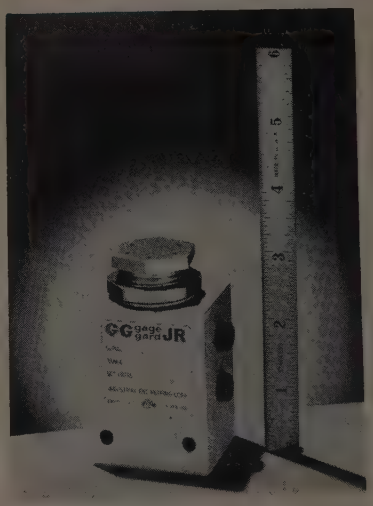


The Tri-angular balanced hydraulic torque wrench is a self-contained device that can easily torque or untorque aircraft, gear transmission and jet engine assemblies, among others, says **Sergan Hydraulics, Inc., Dept. S/A, Manchester, Conn.** The wrench, which is simple to operate, can be made automatic by mounting a double solenoid valve, two limit switch, and external motor-driven pump assembly.

In operation, an equal force is transmitted hydraulically to three power pistons located 120 deg apart. Linear motion is converted to rotary motion by means of a spider arm, which rotates the ratchet wheel through driving pawls. The three load points from the power pistons necessary to rotate the spider arm will always determine a plane or stable hydraulically-balanced load or torque. Three models are available: the ST-40 has a capacity of zero to 4000 ft lbs; the ST-80, zero to 8000 ft lbs, and the ST-200, zero to 20,000 ft lbs.

Write in No. 302 on Reader Service Card

PROTECTIVE DEVICE for instruments



Incline manometers, draft gages, ultra-sensitive transducers and other low-pressure-range instruments can be protected by Gage Gard Jr., a device applicable to either atmospheric or relative pressure systems, says **Industrial Engineering Corp., Dept. S/A, 526 E. Woodbine, Louisville 8, Ky.** It is available in four ranges over the span of −15 to +85 psig, and it withstands after-cutoff pressures of up to 300 psi.

The protector is repeatable and will reopen after sealing at two per cent below the cutoff point. Cutoff pressure may be adjusted and reset at any time. Higher-range units are also available.

Write in No. 303 on Reader Service Card

BEARINGS have thin cross-section

The Midget T Series of precision ball bearings help bridge the gap between miniature bearings and conventional inch-series instrument bearings, according to **Split Ballbearing Div., MPB, Inc., Dept. S/A, Lebanon, N.H.** The bearings, which have very thin cross-section dimensions, require up to 15 per cent less volume than counterpart bore sizes in conventional ball bearings.

In addition, the ratio of load capacity to unit volume of bearing is said to be much higher than in conventional inch-series instrument bearings. Sizes now in production have bores of ⅜, ½, ⅝ and ¾ in., with corresponding od's only ¼-in. greater. The bearings can be used in instruments, missile and rocket components, and radar and microwave equipment, as well as in other devices.

Write in No. 304 on Reader Service Card

GYRO for inertial systems

The GG37B is a new hermetic integrating gyroscope that contributes its sensitivity and ruggedness to inertial guidance applications in missiles, satellite launchers, and other vehicles. It exceeds by at least one order of magnitude the drift rate, stability and ruggedness of other types, says **Minneapolis-Honeywell Regulator Co., Dept. S/A, 2747 4th Ave. S., Minneapolis 8, Minn.**

The inertial gyro will stand up under extremes of temperature, shock vibration, and magnetism. Its minimum operating life is about 1000 hr.

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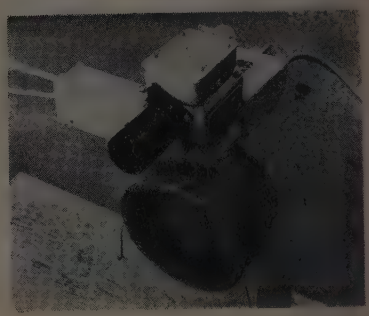
VALVES regulate cabin air



Three six-in. dia valves are contained in a control assembly designed to regulate passenger cabin air on Boeing 707 aircraft, says **Chandler-Evans Corp., Dept. S/A, West Hartford 1, Conn.** Two valves control the cold air supply and the other, the hot air supply.

The butterfly-type valves take about 40 sec for 90 deg travel at temperatures from −65 to +165 deg F. Compartment temperature is thermostat-controlled. Rapid starting and stopping, and accurate timing is obtained through use of a 20,000:1 gear ratio in the actuator.

Write in No. 306 on Reader Service Card

BANDPASS FILTERS cover wide range

These bandpass filters cover wide ranges of frequency with impedances from 50 to 10,000 ohms, with different input and output impedances available for matching purposes, says **Control Electronics Co., Inc., Dept. S/A, 10 Stepar Rd., Huntington Station, N.Y.**

The filters feature low ripple, with minimum insertion loss and attenuation in the pass band, and high attenuation in the stop band.

Write in No. 307 on Reader Service Card

more on page 256

No. 17 • Mars Outstanding Design Series

LIGHT TRAVEL – You may need to postpone your trip a half century or more but you will make up for lost time. So says Philip Schlesinger, of Buffalo, N. Y., who designed this light-powered space ship which will take you to distant space at almost the speed of light.

Based on Einstein's theory that matter can be converted into light, this Photon Powered ship derives its basic power from a small atomic reactor. The reactor is housed in a unit which also contains reflectors. Comparable to fluorescent screens, these convert the reactor heat, under great pressure, into light and thrust. The thrust is low, but extremely constant.

Launched disassembled inside a cargo rocket, the ship is assembled in space. It cannot land (a landing vehicle is provided for that purpose), but remains in orbit.

This is one more example of the creative contributions today's designers are making. To help them translate their pace-setting ideas from concept to reality, they require the best of drafting tools.

In pencils that means MARS, long the standard of professionals.

Among the famous imported Mars drafting products are: **Left** – 1001 Mars-Technico push-button lead holder. **Above** – 1904 Mars-Lumograph drawing leads, 18 degrees, EXB to 9H. **Below** – 2886 Mars-Lumograph drawing pencils, 19 degrees, EXEXB to 9H; 2830 Mars-Lumograph Duralar—for drafting on Mylar®-base tracing film – 5 special degrees, K1 to K5; Mars-Lumochrom colored drawing pencils, 24 shades. **Not shown** – Mars Pocket-Technico for field use; Mars pencil and lead sharpeners; Mars Non-Print pencils and leads.

Mars Products are available at better engineering and drafting material suppliers.

®T.M. FOR duPONT'S POLYESTER FILM

for the man who's going places...

the pencil that's as good as it looks **MARS**

Sold at all good engineering and drawing material suppliers • J. S. STAEDTLER, INC. • Hackensack, N. J.

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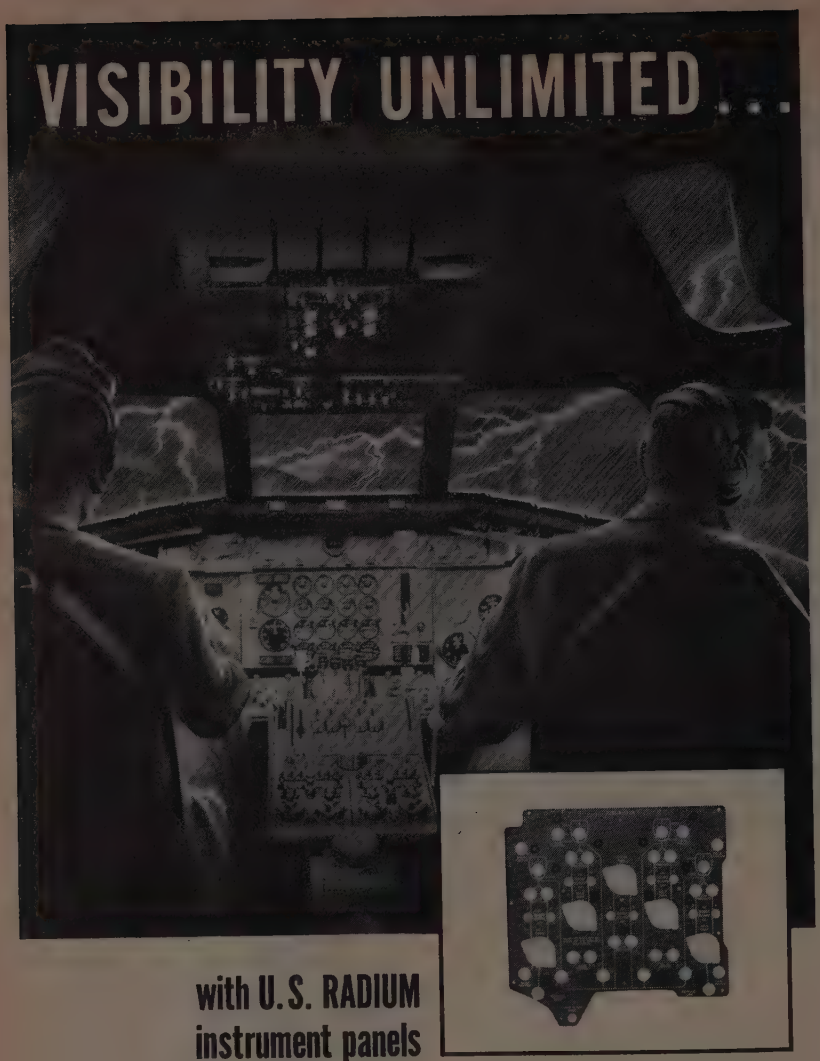
VISIBILITY UNLIMITED . . .



with U.S. RADIUM instrument panels

Outside, blustery weather poses navigational problems for the pilot. Inside, however, edge-lighted panels by U. S. Radium assure maximum ease and efficiency during instrument flight operations.

Only Lackon® panels are engineered to assure maximum legibility at all times, despite variations in illumination level. All meet MIL specification light ratios. While U. S. Radium Lackon® panels are suited for use under darkened conditions, they are readily adaptable for use with natural or artificial light. Contrast between characters and background is especially important in these applications and USR panels are produced in line with such specification requirements.

These are two of the many design advantages obtainable in U. S. Radium Lackon® panels. These and other advanced features are available throughout the entire USR line of edge-lighted panels, dials, knobs and knob skirts for airborne instrumentation and other types of electronic equipment.

The company's consulting engineers are available to discuss your instrument lighting problems. Write Department B6.

UNITED STATES RADIUM CORPORATION

MORRISTOWN, N. J. | Offices: Chicago, Illinois and North Hollywood, Calif. Subsidiaries: Radelin Ltd., Port Credit, Ont., Canada and U. S. Radium Corp. (Europe), Geneva, Switzerland.

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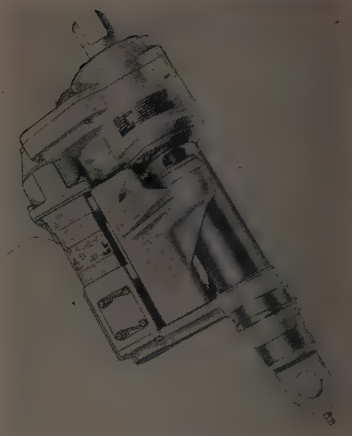
ACTUATOR *is lightweight*



A 28-V dc linear power actuator, originally designed to control and position a horizontal stabilizer in a bomber aircraft, is readily adaptable to missile, ordnance and other applications, says **Hoover Electric Co., Dept. S/A, Hangar Two, Port Columbus Airport, Columbus 19, O.** Normal load of the Model D-2810 is 7500 lbs, proof load is 28,000 lbs, and travel rate is 0.140 ips; other ratings are available.

The 18-lb device has an adjustable position transmitter to operate with an autopilot in a closed loop circuit. Relubrication of the gear box or jackscrew is unnecessary for at least 100,000 cycles, and the actuator has a micro-adjustable end fitting for ease of adjustments in increments of .003 in., without removing the actuator from the mounting structure.

Write in No. 308 on Reader Service Card

PNEUMATIC HOSE has high burst rating

A minimum 24,000 psi is the rated burst pressure of this Teflon hose for 6000-psi systems, says **Aeroquip Corp., Dept. S/A, Jackson, Mich.** The rugged Type 678 hose is designed for the more severe requirements of missile pneumatic charging systems.

Fast, easy purging and dehydration of hose lines and equipment has been made possible by the use of a Teflon tube with zero moisture absorption and an anti-adhesive surface. Spirally-wound stainless steel wire over a stainless inner braid reinforces the flexible hose, which is available in ⅜ and ½-in. sizes. Segmented fittings for the hose have a lip-seal for permanent leakproof performance, and they are reusable. Also available is the Type 675 hose, a lighter-weight pneumatic hose for 3500-psi systems.

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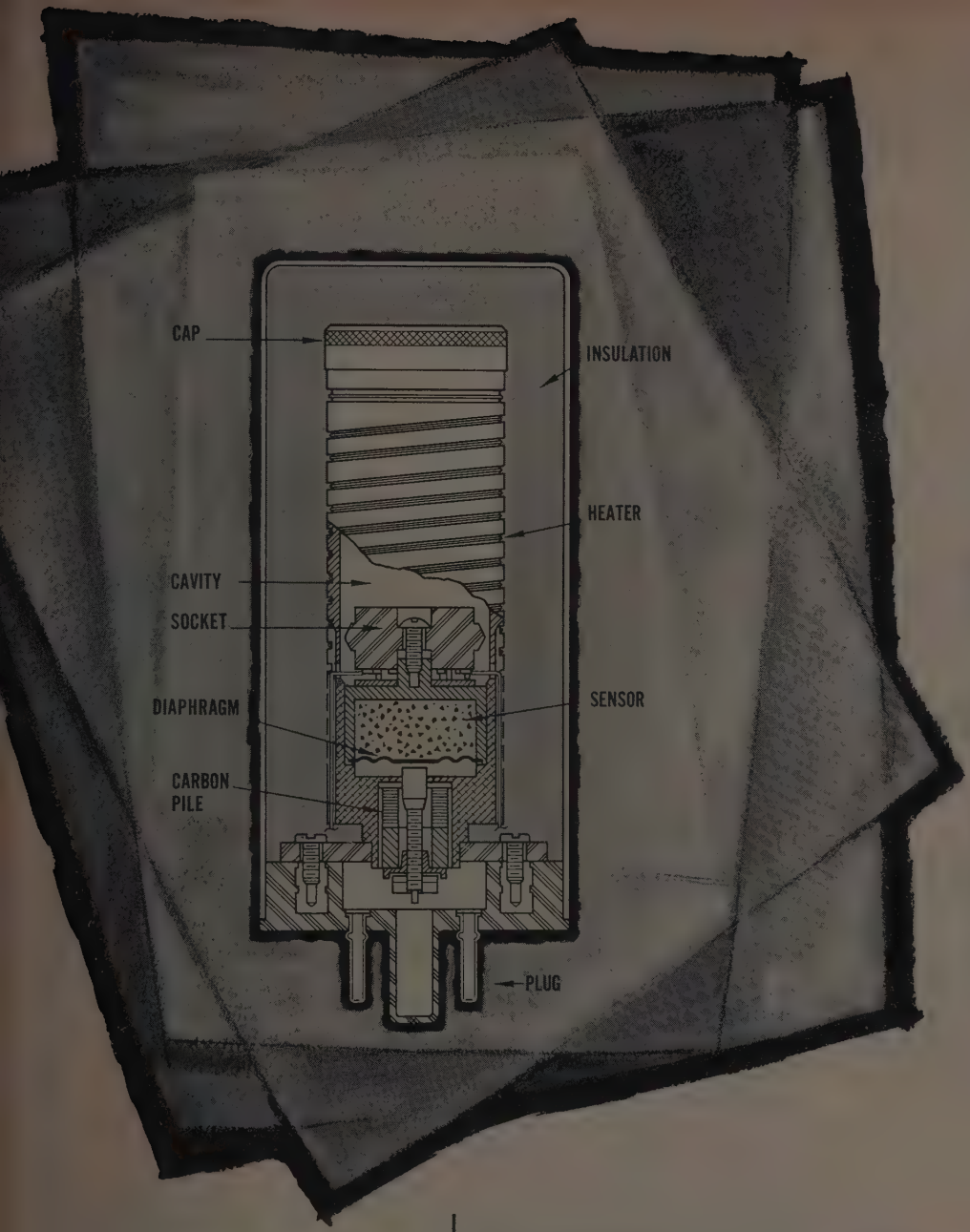
more on page 260



NOW — CIRCUIT SIMPLICITY THROUGH ABSOLUTE TEMPERATURE CONTROL

Robertshaw Crystal Oven Solves Temperature Compensation Problems

APPLICATIONS

Crystals
Crystal Oscillator Circuits
Zener Diodes
Thermocouple Reference Junctions
Transistorized Circuitry
Tuning Forks
Thermistors
Reference Networks
LC and RC Oscillator Circuits

Design engineers can now eliminate temperature compensating circuits and still use inexpensive, temperature sensitive components by housing critical elements in Thermal-Set, Robertshaw's latest change-of-state crystal oven. The reason—Thermal Set's extremely accurate temperature control. To accomplish this, Robertshaw has incorporated two basic features uncommon to conventional ovens—thermal stability and thermal constancy. Thermal stability, or the absence of temperature drift with time, is attained by using the melting point of pure crystalline salt as an absolute and unvarying temperature reference standard. Thermal constancy, the absence of cyclical temperature variation, results from using a proportional heat control system. Combined, these features offer unmatched thermal accuracy . . . the key to optimum system performance.

SPECIFICATIONS *Standard Cavity Temperature:* 53°C, 70°C, 87°C. *Temperature Control:* 0.007°C average cavity temp. change per degree ambient changes. *Heater Voltage:* 6.3 volts AC or DC ± 5%. *Heater Power:* 4.0 watts max. @ 25°C. *External Dimensions:* 1-7/16" x 1⅞" x 4-1/16" seated height. *Cavity Dimensions:* 0.92" dia. by 1.625" deep. *Weight:* Approx. 6.15 oz. *Mounting:* Octal Plug. *Cavity Sockets Available:* Standard 2 or 9 pin. Special configurations and more exacting performance characteristics available on special order. Complete information in Technical Bulletin RF-594. **Robertshaw-Fulton Controls Co., Aeronautical and Instrument Division, Santa Ana Freeway at Euclid Avenue, Anaheim, California.**

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KEARFOTT PRECISION RESOLVERS FOR EVERY SYSTEM APPLICATION

Kearfott has available a complete line of precision resolvers for every system application. Computing resolvers range in functional accuracy from 0.1% to .005%, in bridge accuracy from 5 minutes to 20 seconds of arc and in size from 11 to 25. Non-compensated resolvers range from 5 minutes to 20 seconds of arc in accuracy, from 8 to 25 in size.
All Kearfott resolvers feature stainless housing, shafts and bearings and corrosion-resistant lamination materials for maximum environmental resistance. Optional designs available for operation at 200°C and in environment of 2000 cps vibration at 30 g's.

Computing Resolvers

Available with integral compensating windings. Can be provided with trimming networks to match existing isolation amplifiers or Kearfott-designed transistorized amplifiers.

Size 11

For applications where size and good functional accuracy are of paramount importance. Functional accuracy as good as 0.1% and bridge errors of 3 minutes of arc are in production.

Size 15

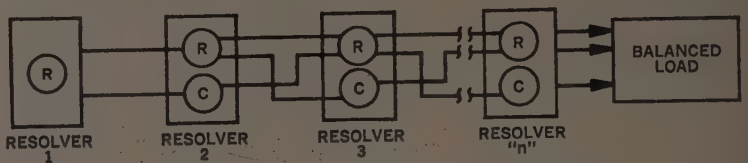
A 2:1 improvement in functional accuracy obtained in this configuration. Unit tabulated is the direct equivalent of standard Navy BuOrd Mark 4 Mod 3 and contains necessary trimming network for standard buffer amplifiers. Transformation ratio is 1.000 ± .0001, phase shift 0° ± 1 minute. Functional accuracy of .05% and bridge error of 3 minutes of arc are standard.

Size 25

For applications demanding the highest order of accuracy. Close attention has been paid to design parameters.

Size 18

A special resolver which permits a unique cascading of these units without the necessity for buffer amplifiers. Typical application is illustrated in following cascade:



R=RESOLVER C=INTEGRAL COMPENSATOR

COMPENSATED RESOLVERS FOR PRECISE COMPUTER APPLICATIONS

SIZE	11		15	18	25
PART NUMBER	R980-01	R980-41	T980-51	V980-004	425506-1
Excitation Volts—(Max.)	60	60	26	26	115
Excitation Volts (Test)	10	10	15	13	25
Frequency—(cps)	400	400	400	400	400
Primary Impedance	629 + j2510	450 + j2200	220 + j1000	3000 + j (0 ± 40)	1630/78.5°
Secondary Impedance	695 + j2750	500 + j2300	240 + j1100	3000 + j (0 ± 40)	1620/80°
Transformation Ratio (Primary to Secondary)	.980	.980	.980	.775	.980
Transformation Ratio (Compensator to Rotor)	.985	.985	.950	.775	.985
Phase Shift (Lead)	8.5°	7.5°	8.5°	0° ± 10'	2.1°
Fundamental Null (MV)	15	15	8	15	15
Bridge Error From E.Z. (Max.) Primary	*7 mins. Stator	*5 mins. Stator	*5 mins. Stator	3 mins. Stator	0.7 mins. Stator

*Also available 3 mins. from E.Z.

Non-Compensated Resolvers

Basically for application in precise data transmission systems. These synchro resolvers permit system designer to achieve system errors of better than 1 minute of arc without using 2-speed servos and elaborate electronics. By proper impedance matches up to 64 resolver control transformers can also operate from one resolver transmitter.

Size 11

Where size is important. These units have a maximum unit error of 3 minutes of arc.

Size 25

Where highest accuracy is required. These units have a maximum error as low as 20 seconds of arc.

NON-COMPENSATED RESOLVERS FOR PRECISE DATA TRANSMISSION

	SIZE 11			SIZE 25		
Type Resolver	Transmitter	Differential	Control Transformer	Transmitter	Differential	Control Transformer
Part Number	R982-004	R982-002	R982-012	Z5161-001	Z5191-001	Z5151-003
Excitation Volts (Max.)	26	11.8	11.8	115	90	90
Frequency (cps)	400	400	400	400	400	400
Primary Impedance	170/77°	95/80.2°	2000/80°	400/82°	800/80°	8500/82°
Secondary Impedance	42/80.5°	110/75.7°	8000/76°	260/82°	900/80°	14000/82°
Transformation Ratio	.454	1.000	1.906	.7826	1.000	1.278
Max. Error from E.Z. Primary	3 mins. Rotor	3 mins. Stator	3 mins. Stator	20 seconds Rotor	20 seconds Stator	20 seconds Stator

Write for complete data.

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.
A subsidiary of General Precision Equipment Corporation
Sales and Engineering Offices: 1500 Main Avenue, Clifton, N. J.
Midwest Office: 23 W. Calendar Avenue, La Grange, Illinois
South Central Office: 6211 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, California

Kearfott — A GENERAL PRECISION COMPANY

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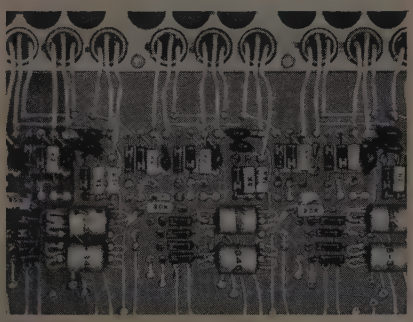

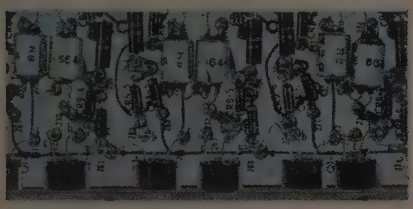

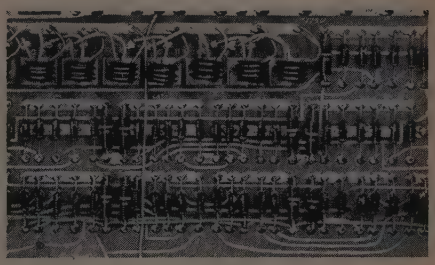

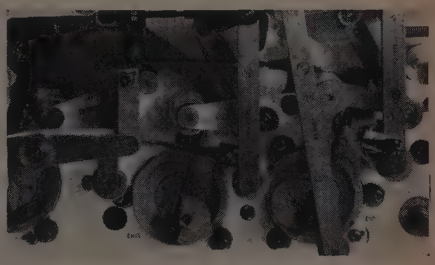

what goes into a computer system.....

...more than experienced engineering, more than parts, plans and programs. At Librascope, it is the ability to integrate components and brain-power into workable computer systems for the accurate translation of data.

Librascope engineers attain optimum system accuracy by weighing problems in terms of inputs available and outputs required to provide reliable answers.

This process, from concept to reality, has unlimited room for expression at Librascope where facilities including field test and simulation laboratories cover hundreds of thousands of square feet... where research—development of electronic, electro-mechanical, magnetic and optical computing techniques is a continuing, progressive program.

What goes into a Librascope computer system represents the best experience of two decades. For full details on how Librascope can anticipate and solve your computer and control problems, write...

For information on career opportunities at Librascope, write Clen Seltzer, Employment Manager.

LI 9-2

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WICKWIRE ROPE
A CF&I PRODUCT

FROM AIR ASSOCIATES

...get prompt delivery from warehouse stocks maintained at or near airports in:

Atlanta, Ga. • Chicago, Ill. • Cleveland, Ohio • Dallas, Tex. • Kansas City, Kansas • Los Angeles, Calif. • Miami, Fla. • San Francisco, Calif. Teterboro, N. J. • Tulsa, Okla. • Wichita, Kansas

You'll find that Air Associates Division of Electronics Communications, Inc. maintains ample stock of CF&I-Wickwire Aircraft Control Cables at all its strategically-located warehouses. Air Associates will furnish, on short notice, wire rope for aircraft tiedown systems.

You get top quality when you buy CF&I-Wickwire Rope. And you get fast service when you order it from an Air Associates warehouse. 6959

Write in No. 150 on Reader Service Card at start of Product Preview Section

TINY MOTOR develops high thrust

This miniature, squib-actuated piston motor, which provides positive displacement for the performance of mechanical work, should be of special interest to designers of missiles, weapons, and weapon systems, says **Atlas Powder Co., Dept. S/A, Wilmington 99, Del.** Actuated by as little as 100 ergs at 1.5 V, or 0.2 amps, it is capable of providing 20 lbs of thrust over a 1/64- to 5/16-in. stroke, within an elapsed time of one msec.

The motor will operate properly between −65 to +165 deg F, and it will withstand 20,000 g's shock and acceleration. It is ¼ in. in dia and 15/16 in. long.

Write in No. 313 on Reader Service Card

more on page 262

USE THIS NEW KIND OF DIAMOND CUT-OFF WHEEL

Gives narrower, smoother cuts on industry's toughest materials

...yet prices start at only $32.25

Now... at *production prices*... DIATRONIC gives you a rim width of .006" that's accurate to a maximum total tolerance of .0005"—or your money back. This accuracy is built in by a new process. No break-in needed. New narrow cut reduces sawdust loss 30%. A must for $3,000-a-pound silicon or germanium crystal. Cuts tungsten carbide, corundum, aluminum oxide, glass... practically anything. Stock orders shipped in hours; special wheels available. Write for literature, price list.

Another invention marketed by
NAVAN PRODUCTS, INC.
Subsidiary of North American Aviation, Inc.
Dept. 173, International Airport, Los Angeles 45, Cal.

DIATRONIC* DIAMOND WHEELS
"with built-in tolerance" *TRADEMARK

A Match for any Gyro's Torque!

Each matched pair of MPB spin bearings is precisely duplexed to keep motor speed constant and torque low even under severe thrust loads. Noiseless operation . . . life-long lubrication. Interested? Details from MPB, Inc., 1406 Precision Park, Keene, N. H.

MPB helps you perform miracles in miniaturization

MPB

MINIATURE PRECISION BEARINGS INC.

Write in No. 197 on Reader Service Card

LOOK FOR THE DIAMONDS—SIGN OF FINISHING QUALITY

Only IRIDITE®

Process Engineered

Chromate Conversion Coatings

Give you 5 additional benefits for Corrosion Protection—Paint Base—Decorative Finishing

1 A COMPLETE PROCESS ENGINEERED LINE

Developed for specific applications, there is an Iridite to provide the finish you desire, fit the equipment you have available and give the performance you require. Most Iridite coatings meet rigid military and civilian specifications.

2 EXPERIENCED TECHNICAL SERVICE

Our large field engineering staff is thoroughly familiar with chromate conversion coatings and related finishing operations. They'll help you check every step in your finishing operation to make sure you're getting the best possible finish on your products.

3 PRODUCT AVAILABILITY

Warehouses located in strategic industrial areas enable us to provide you with fast, economical delivery on any Iridite.

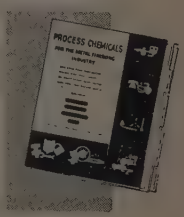
4 ECONOMY

The superior performance of Iridite provides low final cost by extending operating life and lowering maintenance costs. In addition, Iridite gives you a finish that adds considerably to the value of your product. There's an Iridite to meet every cost and performance requirement.

5 RESEARCH AND DEVELOPMENT FACILITIES

If you have an unusual application, we will gladly work with you. Our entire staff of experienced engineers and chemists, and our completely equipped facilities are at your service.

IRIDITE—a specialized line of chromate conversion coatings for non-ferrous metals. Apply by dip, brush or spray methods — at room temperature — manually or with automatic equipment. Forms a thin film which becomes an integral part of the metal. Cannot chip, flake or peel. No special equipment, exhaust systems or specially trained personnel required.



If you are using chromate conversion coatings to finish zinc, cadmium, aluminum, magnesium, silver, copper, brass or bronze — consider the above benefits of Iridite. For complete information, contact your Allied Field Engineer. He's listed under "Plating Supplies" in the yellow pages. Or, write for FREE TECHNICAL DATA FILE.

Allied Research Products, Inc.

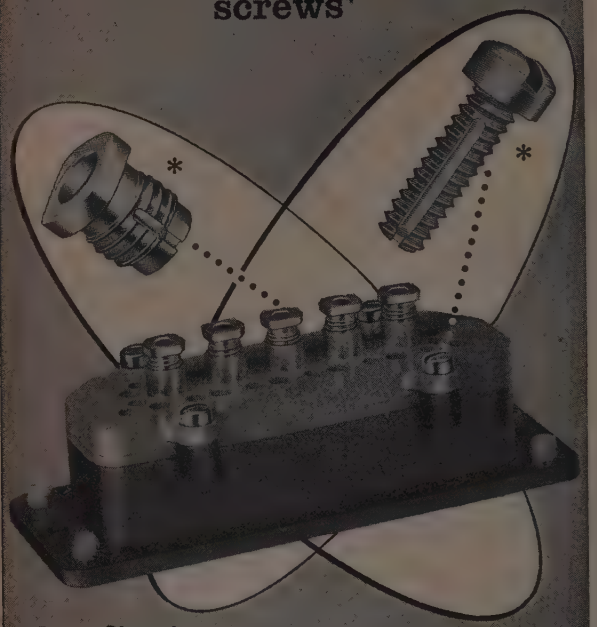
4004-06 EAST MONUMENT STREET • BALTIMORE 5, MARYLAND
BRANCH PLANT: 400 MIDLAND AVENUE • DETROIT 3, MICHIGAN
West Coast Licensee for Process Chemicals: L. H. Butcher Co.

Chemical and Electrochemical Processes, Anodes, Rectifiers Equipment, and Supplies for Metal Finishing

IRIDITE® Chromate Coatings	IRILAC Clear Coatings	ISOBRITE® Plating Brighteners	ARP® Chemicals & Supplies	WAGNER Line of Equipment

Write in No. 198 on Reader Service Card at start of Product Preview Section

CANNON selects
LONG-LOK self-locking
screws*

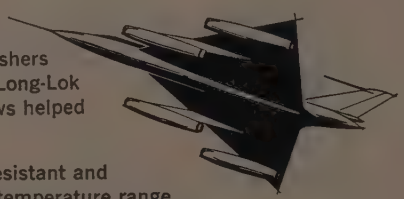


for first
all-magnesium
environmental
connector.

USED ON CONVAIR'S B-58
SUPERSONIC "HUSTLER"

Two of the prime requirements of this Cannon Electric connector were that it be lightweight and fully environmental.

Because they eliminate lock washers and safety wire, Long-Lok Self-locking Screws helped save weight.



Being vibration-resistant and spanning a wide temperature range, Long-Lok Self-locking Screws solved two important environmental requirements.

Whether you have critical or normal fastener problems, Long-Lok Self-locking Screws can speed and improve your assembly operations. Available for both aircraft and commercial applications.

Write for free Bulletin LL-58.

LONG-LOK
CORPORATION

2601 COLORADO AVENUE • SANTA MONICA, CALIFORNIA

Write in No. 199 on Reader Service Card

POLARIZED RELAY
designed for long life

The Type 51 polarized relay, available in bi-stable or center-stable models, is suited to a variety of aircraft and electronic applications, says **C. P. Clare & Co., Dept. S/A, 3101 Pratt Blvd., Chicago 45, Ill.** These include use in bridge circuits as a null-sensing device without amplifiers, electronic controls, supervisory circuit monitoring, and servomechanisms.

The relay is said to be free of contact bounce and capable of one million accurate response cycles without readjustment. Sensitivity is one to three amp-turns and two to five amp-turns for the center-stable Type 51M and the bi-stable 51A, respectively. The 5.5-oz unit is stable over −40 to +70 deg C, will withstand 4000 shocks at 40 G, and resist vibration up to 150 cps at 0.006 in., double amplitude. Operating time is 0.7 msec.

Write in No. 355 on Reader Service Card

SERVO AMPLIFIER
is completely transistorized

Model A3300-01 servo amplifier is designed primarily for operation from a 115 V, 60 cps power supply. The amplifier has an internal dc supply, low transistor dissipation, eliminates load tuning capacitor, provides 90-deg phase shift, is rugged, and features easy gain adjustment, says **Kearfott Co., Inc., Dept. S/A, 1500 Main Ave., Clifton, N.J.**

The input impedance of the amplifier is 5 to 100 K; input power is 16 W. Maximum signal input is 30 V rms. Output voltage is 40 V at 60 cps. The gain stability (0 to +50 deg C) is ±4 db. The effective gain can be adjusted from 80 to 1000 by inserting an external resistor of proper value. The unit may be modified easily for 400-cps servo motors.

Write in No. 356 on Reader Service Card

DC-DC CONVERTERS
are transistorized

This QC series of dc-to-dc converters provides an economical, efficient means of obtaining higher voltages from standard 6-, 12-, or 28-V dc sources. Standard output voltages range from 50 V dc (30 V dc on 12-V models) to 1000 V dc, says **Sorenson & Co., Inc., Dept. S/A, Richard Ave., S. Norwalk, Conn.**

Powers available are 200 W in 12-V models 150 W in 28-V models, and 90 W in 6-V models. Tubeless circuitry, instantaneous starting, and low noise level recommend the QC series for both commercial and military applications.

Write in No. 357 on Reader Service Card

BRAZING ALLOY
for high temperature use

High-strength joints for continuous service at temperatures up to 2000 deg F are produced by a new nickel-chromium-boron brazing alloy, Nicrobraz 170, says **Wall Colmonoy Corp., Dept. S/A, 19345 John R. St., Detroit 3, Mich.** It will satisfactorily braze tungsten and molybdenum bearing alloys, and it can be used up to 2200 deg F.

Improved ductility, good wetting characteristics, and flow that is satisfactory in shallow joints and excellent in pure, dry hydrogen and vacuum atmospheres are among the brazing alloys featured. The recommended brazing range is 2150 to 2200 deg F in pure, dry hydrogen. The material is available in powder form.

Write in No. 358 on Reader Service Card

more on page 266

Write in No. 200 on Reader Service Card

Missiles designed to soar out of this world ...are speed by liquid oxygen from LINDE

Oil, kerosene, and alcohol "burn" by combining chemically with oxygen from the air. But it takes pure oxygen with these fuels to speed rocket planes faster than sound . . . to drive missiles beyond the earth's atmosphere.

Liquid oxygen, vital to today's rocket engines and many types of missiles, was being produced by LINDE as long as 25 years ago. In fact, LINDE has been supplying oxygen to industry for more than 50 years. LINDE pipes oxygen directly to industrial users from nearby oxygen plants built and operated by LINDE. The user makes no capital investment, and pays only for the oxygen consumed —at a price guaranteed by LINDE.

LINDE also developed methods for transporting liquid oxygen efficiently, in large and small amounts, at 300 degrees below zero F. You can get LINDE oxygen in just the quantity you need, at the exact time and place you want it, as a liquid or a gas.

For detailed information about LINDE oxygen, write Dept. J-6, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in other principal cities. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

When you need Oxygen—call LINDE!

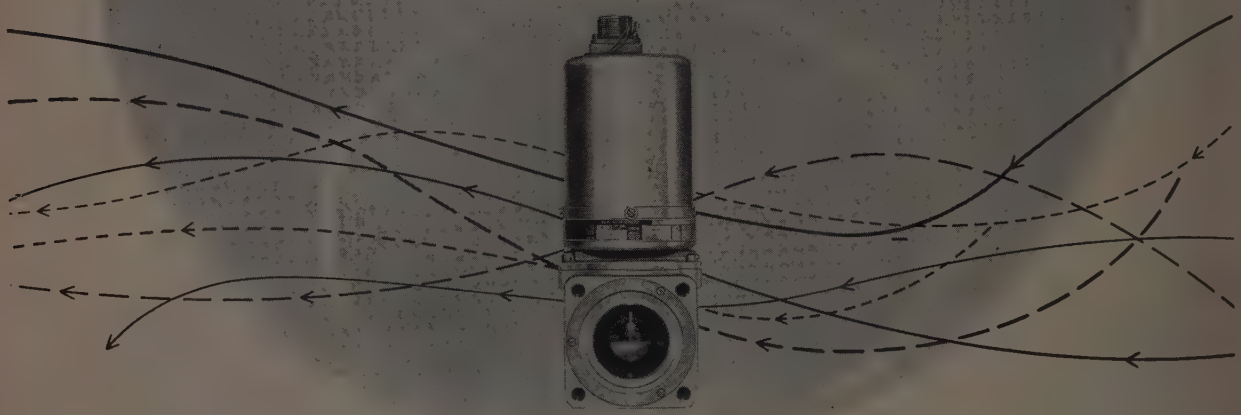
The terms "Linde," "Driox," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Liquid oxygen from LINDE's DRIOX oxygen units is teamed with liquid fuels to propel missiles and rocket planes.

Linde
TRADE-MARK

UNION CARBIDE

WHITTAKER SPHERICAL PLUG VALVES



RELIABILITY—PLUS UNLIMITED SCOPE FOR FLUID-FLOW CONTROL

These compact valves afford split-second control in high pressure and cryogenic flow systems. Whittaker's spherical plug construction provides the efficiency of "straight-through flow" with negligible pressure drop—almost constant low operating torque regardless of pressure ...*for unlimited advantages of flow control!* Available in a wide range of sizes, each valve is designed to customer specifications—may be actuated manually, pneumatically, hydraulically, or electrically. Since 1955, Whittaker Spherical Plug Valves have been produced in quantity for both missile and aircraft applications—let Whittaker engineers help *you* with your design problem. Write, wire, or phone.

Time-proven Reliability
In Hydraulic-Pneumatic-Fuel Controls

WC

WHITTAKER CONTROLS
DIVISION OF TELECOMPUTING CORPORATION

915 N. Citrus Ave., Los Angeles 38, Calif. • HO 4-0181

BRANCH OFFICES: New York, Dayton, Seattle, Wichita, Atlanta

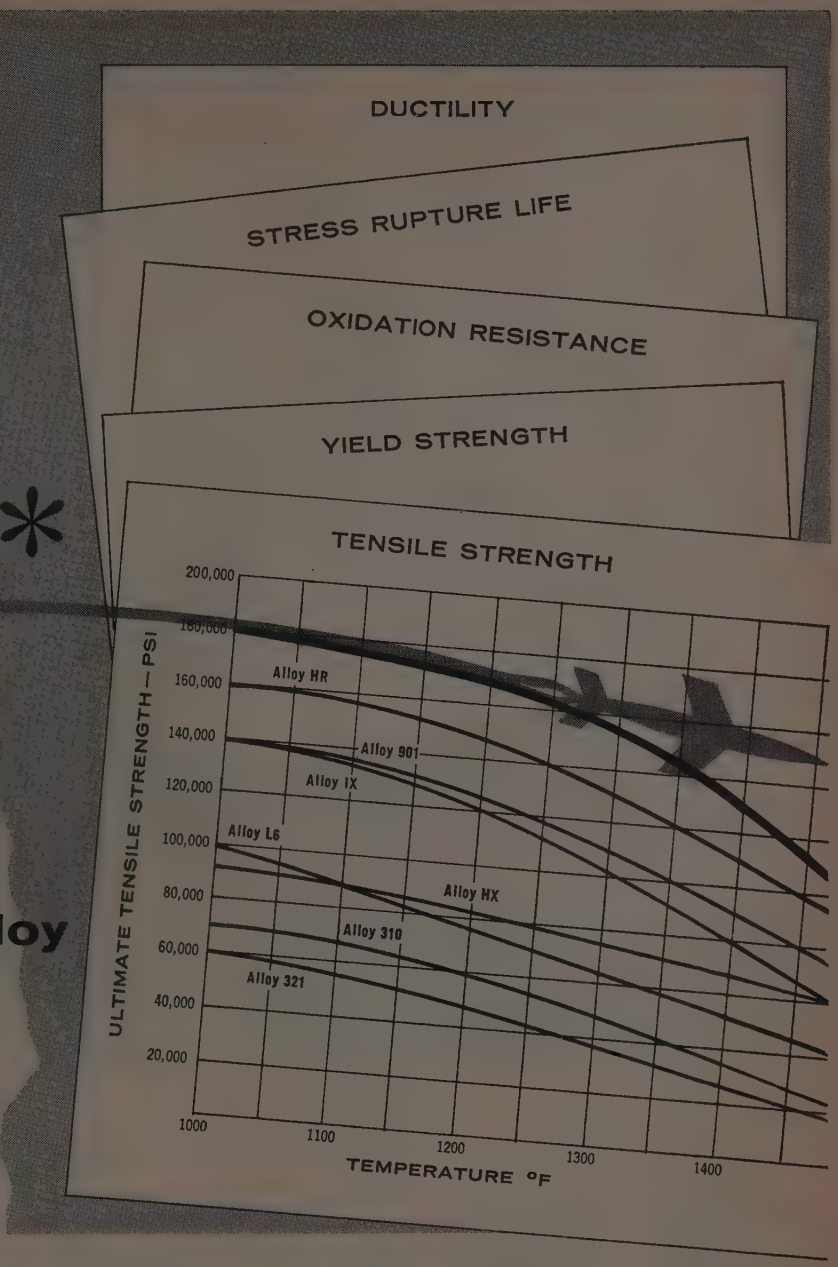
Write in No. 201 on Reader Service Card at start of Product Preview Section

HIGH

on every chart:

RENÉ 41*

most dependable alloy in use today in the 1200°-1800° F range



In *all* ways, René 41 is a remarkable alloy. No other high-temperature alloy used in production today equals its tensile strength. In other properties, too, René 41 is far ahead of the field.

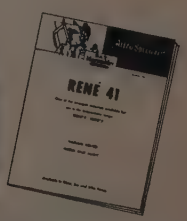
Also important, this nickel-base, vacuum-melted alloy is easy to work with. It's readily formable by drawing, bending, spinning — welds to similar or dissimilar materials.

Cannon-Muskegon offers René 41 in standard 36″ x 96″ sheets .015″ to .125″ thick, in smaller sizes down to .010″, in bar stock up to 3″ in diameter . . . foil down to .001 in thickness . . . and fine wire only .0015 in diameter.

For complete details, write for Technical bulletin No. 86.

*TM of General Electric Co.

ULTRA MET
VACUUM ALLOYS



CANNON-MUSKEGON CORPORATION

2887 Lincoln Avenue • Muskegon, Michigan

METALLURGICAL SPECIALISTS

Write in No. 202 on Reader Service Card at start of Product Preview Section

1-59

For Safe Flexible Fluid Handling Lines— specify CHIKSAN Swivel Joints

FOR MISSILE FUELING

Swivel Joints and assemblies to handle cryogenic liquids and fuels in ground loading and topping hose. Assemblies developed to handle services ranging from −320°F to +600°F and pressures from 20″ vacuum to 15,000 psi.

FOR GROUND SUPPORT EQUIPMENT

Loading arms and flexible transfer assemblies for handling Lox, N_2, He, JP Fuels, H_2O_2 and Hot Gases. Sizes range from ¼″ to 16″. Corrosion resistant steel, nickel, brass, aluminum, bronze and other metals available.

FOR GROUND HANDLING EQUIPMENT

Swivel Joints and assemblies to handle hydraulic, pneumatic, and fuel systems on launching vehicles and missile transporters. Units for rotation in 1, 2 or 3 planes in widest variety of metals, pressure and temperature available.

FOR AIRCRAFT SYSTEMS

Compact, lightweight package units in ¼″, ⅜″, ½″ and ⅝″ O.D. tubing sizes. Pressures of 28″ vacuum to 4,000 psig. Temperatures of −65°F to +275°F. AN and MS standard end connections.

CHIKSAN COMPANY

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

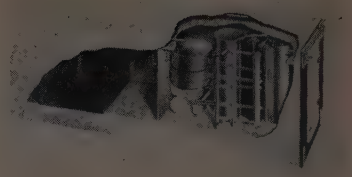
CHIKSAN COMPANY—BREA, CALIFORNIA

Send for informative Bulletin 558

59-41

Write in No. 203 on Reader Service Card at start of Product Preview Section

FLIGHT DATA RECORDER is self-contained



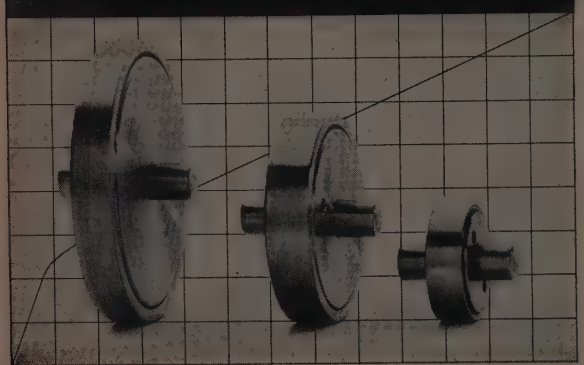
This unit is a completely self-contained mechanical-scribe-type recorder for sensing and recording all CAA TSO requirements except vertical acceleration. An external accelerometer is provided. Flight information is inscribed on a specially coated and almost indestructible metallic tape. The magazine holds 200 ft of tape, which will allow 200 hours of flight data recording, says **Waste King Corp., Technical Products Div., Dept. S/A, 5550 Harbor St., Los Angeles, Calif.**

Both sides of the tape can be used, and a total of 14 channels of information can be accepted. The 20-lb unit is contained in a standard long-½-ATR equipment case. A transparent plastic window allows inspection of the recording process.

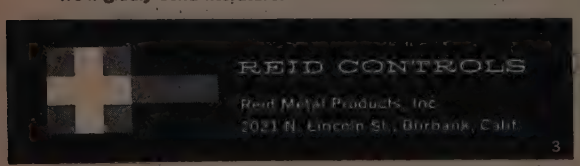
Write in No. 314 on Reader Service Card

more on page 268

MINIATURE ROTARY POSITIONING CONTROLS



Inch Ounces to 65 Inch Lbs.—Precisely, positively held in an infinite number of positions. Clockwise or counter-clockwise rotation. No backlash. Low breakaway torques. Vibration proof. Applications include no-back, potentiometer positioner, dial control, clutch, coupling, etc. Patented principle. Diameters ¾″ to 1¾″. Depth ⅝″. We'll gladly send literature.



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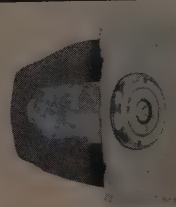


PUSH IN

TWIST OUT

new from OHIO

EASY-ACTION, QUICK-CONNECT

AIRCRAFT OXYGEN OUTLET

This unique, flush-mounted oxygen outlet features a retractable, self-purging dust cap that never needs to be removed or pushed aside. It's easy to operate, too — just a soft push to insert and a quick twist to remove. Lightweight — (under 1 oz.) — this outlet is functionally designed — only one moving part. Here is the same principle that has been proved in thousands of hospital pipeline installations — now adapted for aircraft use!

For complete data and free engineering aid from specialists in oxygen piping systems, please write to Aviation Dept.

OHIO

Ohio Chemical

OHIO CHEMICAL & SURGICAL EQUIPMENT CO.

Madison 10, Wisconsin

AIRCO (A Division of Air Reduction Company, Inc.)

Write in No. 200 on Reader Service Card

Each new BOMARC missile base will protect thousands of square miles

This is a section of the Hurlburt Field installation at Eglin Air Force Base, Florida, for the supersonic BOMARC area-defense missile. Other bases are now nearing completion.

The BOMARC missile, in volume production for the U. S. Air Force, is the most advanced defense missile in the nation. It flies farther, reacts faster, has greater tactical flexibility and a higher "kill rate" per dollar against attacking aircraft than any other defense missile.

The BOMARC's long reach—200 to 250 miles—enables each BOMARC base to provide interceptor cover over thousands of square miles. The result is economy, *and* more effective defense. BOMARC's longer range enables it to destroy attack forces—either aircraft or airborne missiles—long before they can reach U. S. borders.

BOMARC is backed by more than 13 years of Boeing experience in the missile field. Throughout an exhaustive test program, the BOMARC missile, as well as its guidance, propulsion, support and other subsystems, has demonstrated outstanding performance and reliability. BOMARCs have intercepted bombers, jet fighters and supersonic missiles. They have been successfully fired and controlled in salvo. Single BOMARCs can destroy multiple targets. BOMARC, moreover, can be developed to cope with intercontinental ballistic missiles.

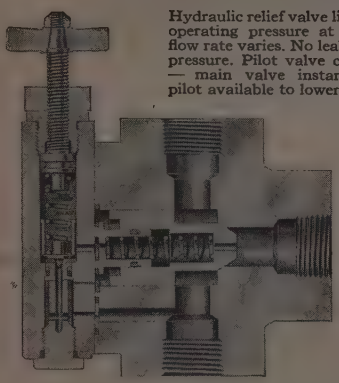
BOMARCs are designed to operate integrally with SAGE, the joint American-Canadian air-defense detection and control system. The BOMARC system has been chosen by the Canadian Government as an integral part of its air defense.

BOEING BOMARC

REPUBLIC VALVES
FOR EVERY INDUSTRY

RELIEF VALVES
WITH
• EXCLUSIVE FEATURES
• SMOOTH OPERATION
• LONG LIFE

PILOT-OPERATED RELIEF VALVE

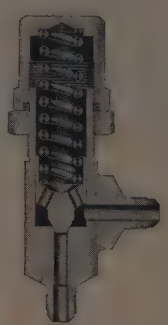


Hydraulic relief valve limits system's maximum operating pressure at constant level, though flow rate varies. No leakage loss below cracking pressure. Pilot valve controls pressure setting — main valve instantly conforms. Remote pilot available to lower setting of integral pilot control. 3 pressure ranges: 50 to 1200 psi; 1000 to 3000 psi; 2500 to 5000 psi. 50,000 tensile semi-steel body standard aluminum alloy to order. FMP or str. thread gasket seal bosses, ¼" to 1¼". Panel mounting bosses.

Modified units available as Sequence Operating Valves; and as Unloading Valves for clamping or other two-pressure applications.

POPPET TYPE RELIEF VALVE

Smoothly sliding poppet, seated by a stainless steel compression spring is the simple design of this rugged unit. External adjustment. Two types of sealing elements available. Soft seal poppets for air, gas, and liquids, with no leakage; stainless steel poppet for general hydraulic applications. Other poppet materials available for special chemical services. Eleven pressure ranges to 2750 psi, ⅛" to ¾" pipe, tubing, internal straight threading. 250°F std — specials to 400°F. Aluminum alloy, brass, or stainless steel.



ADJUSTABLE IN-LINE RELIEF VALVE

External relief adjustment without breaking line is the feature of this 5000 psi relief valve. Limits hydraulic system's maximum pressure at constant level, with minimum rise above cracking pressure. Turning locknut on body varies relief pressure adjustment spring in pilot valve. Free reverse flow. 2 pressure ranges: 50 to 2500 psi; 2000 to 5000 psi. Stainless steel body with hydraulic o-ring, −65° to 160°F standard. Packings for other fluids, and higher temperatures available. Flare or flareless tube connections ½" and ¾".

Distributors in principal cities coast to coast

CHECK RELIEF SELECTOR GLOBE NEEDLE PLUG

283

RM REPUBLIC MANUFACTURING CO.
15655 BROOKPARK ROAD • CLEVELAND 35, OHIO

Write in No. 206 on Reader Service Card

STEPPING MOTOR prevents double indexing

Double indexing during shock, vibration, or over-voltage is impossible with this new miniature, high speed stepping motor and switch, says **Data Instruments Div., Telecomputing Corp., Dept. S/A, 12838 Saticoy St., North Hollywood, Calif.** Two models, the Neuron Motostop, which has no stepping switch, and the Neuron Motoswitch, are recommended for programing devices and for sequential operations where precise control is needed in digital-to-analog information conversions.

Two identical stepping motors drive the same shaft in opposite directions. The output shaft rotates 36 deg for each input impulse, up to 40 steps per sec. Both models are available for 24, 48, and 90 V dc and 100 V ac. DC models have a maximum input power rating of 12 W; ac models, 15 W.

Write in No. 360 on Reader Service Card

DIGITAL VOLTMETER has increased accuracy

Model 501 digital voltmeter has an added fifth digit to ensure accuracy at the upper limit of each range. The unit has an accuracy of 0.01% ±1 digit in four automatic ranges from 0.0001 to 1000.0 vdc and retains this accuracy in the transition area between ranges says **Cohu Electronics, Inc., Kintel Div., Dept. S/A, Box 623, San Diego 12, Calif.**

The unit readout has a total of 6 display windows with the sixth showing polarity. The decimal point is located automatically as part of the range selection.

Write in No. 361 on Reader Service Card

GEARHEAD has adapter clamp

The 750GH servomotor gearhead is equipped with a double-lipped clamp to permit instant adaptation to Size 8 motors, says **Bowmar Instrument Corp., Dept. S/A, 8000 Bluffton Rd., Fort Wayne, Ind.** It is particularly useful where motors have no provisions for screw-mounting gearheads.

In addition to imparting greater rigidity to the overall assembly the clamp provides a uniform clamping pressure that can't cause warpage or other uneven strains. Post-type construction of the gearhead has been abandoned for a technique that uses precision-machined elements to hold end plates and bearings in position. The design contributes to improved vibration and shock resistance, increased accuracy, and permanency of component alignment.

Write in No. 362 on Reader Service Card

FREQUENCY METER has high accuracy

Model D-W-E 1021 frequency meter provides broad RF band coverage and accuracy to 0.005%. It measures frequencies from 125 kc to 1000 mc and generates voltages of known frequency from 125 kc to well above 1000 mc, says **Divco-Wayne Electronics, Dept. S/A, 9701 Reading Rd., Cincinnati 15, Ohio.**

Each meter is pre-conditioned in a Tenney environment chamber for conditions under which it will actually operate. Accurate calibration data is supplied for 5000 dial readings. Stability is better than 0.0025. RF output is 100 uv into 50 ohm load for the fundamental and 50 uv into 50 ohm load for harmonics, and the RF voltage can be modulated with 900 cps internal oscillator. The unit measures 14 in. by 12 in. by 14 in. and weighs 27 lb (less batteries or power supply).

Write in No. 363 on Reader Service Card

more on page 270

Some Ideas

for your file of practical information on drafting and reproduction from

KEUFFEL & ESSER CO.

A year of relentless testing has produced a small library of interesting facts about HERCULENE (T.M.) Drafting Film. What follows is a consensus of drafting-room experience with HERCULENE—by K&E and its customers—with some up-to-date recommendations for using it. Take the matter of . . .

Shiny Back vs. Pencil Back

A basic question is: do you need a double-surfaced drafting film? We make HERCULENE Drafting Film both ways, of course —with a single surface (shiny back) and double surface (pencil back). It's our recommendation that you use pencil back HERCULENE only if it's your practice to make basic drawings on one side, changes on the other. For most other uses, shiny back is preferable. (At first, the double-surface film was chosen by many drafting rooms because it lay flatter on the board than shiny back. This is no longer true. K&E research labs have come up with a fully effective anti-curl treatment.) Especially in filing, shiny back HERCULENE presents fewer problems. The clean non-abrasive back won't smudge the face of the sheet underneath, even in a heavy stack of tracings. If you'd like to compare a few sheets, please let us know.

Note sharp clear lines made by Duralar pencil on HERCULENE Drafting Film.

Plastic Pencils and the HERCULENE Surface

Not just a handy catch-phrase, when K&E puts its exclusive "engineered surface" on a drafting material, the result is an exact, uniform tooth for sharp pencil drawing, inking and typing. With HERCULENE Drafting Film, however, an entirely new type of plastic (non-graphite) pencil yields especially good results. Quite a few of our customers have reported favorably on the well-known Staedtler "Duralar" brand. Duralar pencils come in five hardnesses, are non-smudging and have generally good covering power, sharpness and erasability. After about 20 prints, the Duralar lines show up consistently better than those made by a regular pencil, since graphite lines tend to lose density.

Wet That Eraser!

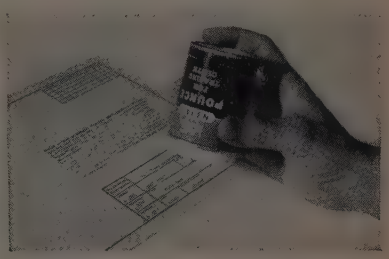
The erasing qualities of HERCULENE Drafting Film are excellent, but (as with the pencils) we've discovered it's a new type of vinyl eraser that gives the best results. Examples of these non-rubber type erasers are the Richard Best "TAD" and the Eberhard Faber "RACE KLEEN" — both available from your K&E dealer. With vinyl erasers, pencil lines whisk off. Even stubborn ink and typing can be removed easily, with no damage to the surface. Here's a tip on how to do this:

Moisten the eraser slightly. It becomes no more abrasive, but a lot more "erasive." Moistening is a must when removing Duralar lines or typing after exposure to heat. (Incidentally, don't use electric erasing machines, steel erasers or typewriter erasers.) When erasing large areas, certain chemical eradicators work fine too. Our suggestion: use Vythene or a very light application of a denatured alcohol such as Solox, both of which can be applied with a cotton swab or clean cloth.

The Cleaner the Better

HERCULENE Drafting Film was designed for ink work, and its ink take is unexcelled. But like all films, its non-absorbency makes a few preparations advisable. The surface should be cleaned thoroughly before inking. Quickest and most effective way to do this is with the ABC Draftsman's Dry-Clean pad, which will remove finger marks and "traffic film" simply by rubbing the pad over the surface. Pouncing will also work well. A damp cloth is all right for general cleaning, but does not do the best job of preparing the surface for ink.

Inking over graphite pencil lines comes out best when done over light lines, drawn with a harder grade of pencil. A good way to remove excess graphite is to go over the drawing with an ABC pad. Inks vary in their usefulness on HERCULENE. We've tested several, and you're welcome to these results as well, on request.



After Typing, Please Pounce

Typed impressions on HERCULENE Drafting Film are crisp and sharp, but may take a while to dry because the film's surface doesn't "swallow" ink readily. A light pouncing right after typing will dry the ink and fix the lines — giving you uniform permanent contrast.

A new typewriter ribbon will produce the best impressions. At K&E we've tested a healthy variety of ribbons and we'd be pleased to send you the results on request.

Outstanding Advantages Proved in Tests

We're pleasantly amazed at the short time it took for HERCULENE Drafting Film to become an accepted "staple" — along with ALBANENE® Tracing Paper and PHOENIX® Tracing Cloth. Actually, it's a rare drafting room by now that has *not* tested HERCULENE during its first year on the market. The findings: All properties considered, HERCULENE stands up better than any other drafting film. It has great resistance to heat, aging and abuse. Its exclusive "engineered surface" plus its tough, durable Mylar® base provide superior pencil and ink take, fine erasability, remarkable dimensional stability...a combination we're proud to call unbeatable!

The K&E dealer near you has HERCULENE now. Stop in and see him.

KEUFFEL & ESSER CO., Dept. AA-6, Hoboken, N. J.

Please send further information about HERCULENE Drafting Film. I'd like samples too.

Name & Title _____

Company & Address _____

_____

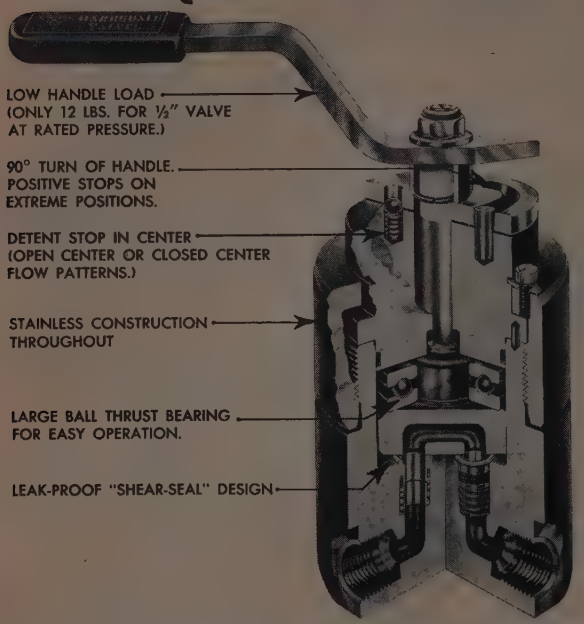
2001

Write in No. 207 on Reader Service Card at start of Product Preview Section

10,000 P.S.I.

4 WAY VALVE

FOR LIQUIDS OR GASES


LOW HANDLE LOAD (ONLY 12 LBS. FOR ½" VALVE AT RATED PRESSURE.)
90° TURN OF HANDLE. POSITIVE STOPS ON EXTREME POSITIONS.
DETENT STOP IN CENTER (OPEN CENTER OR CLOSED CENTER FLOW PATTERNS.)
STAINLESS CONSTRUCTION THROUGHOUT
LARGE BALL THRUST BEARING FOR EASY OPERATION.
LEAK-PROOF "SHEAR-SEAL" DESIGN

This new four-way valve series comes in pipe sizes from ¼ to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

No port to port leakage occurs in the detented positions because of the exclusive "Shear-Seal" design.

Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.

Write for Catalog 58-59

CONTROL VALVE DIVISION **barksdale valves**

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

Write in No. 208 on Reader Service Card

DATA RECORDER
holds tape tension

Remote electronic speed control, fully-transistorized recording and playback modules, and from one to 14 channels are features of the Model C-100 instrumentation tape recorder. A special tape drive produces constant tape tension against the head at any selective speed, between 3¾ and 60 ips, says **Mincom Div., Minnesota Mining & Mfg. Co., Dept. S/A, 2049 S. Barrington Ave., Los Angeles 25, Calif.**

The device accepts input power of any frequency from 45 to 1000 cps, and a 14-channel installation needs 500 W. For telemetering, electronic modules are available for direct recording, frequency modulated or PWM-type systems. There are only 12 moving parts in the entire record-back system.

Write in No. 364 on Reader Service Card

COATING
protects metal surface

The Nicrocoat process can provide sheet metal parts with a furnace-bonded protective surface layer that resists oxidation, abrasion and corrosion, says **Wall Colmonoy Corp., Dept. S/A, 19345 John R. St., Detroit 3, Mich.** It gives to mild steel and other low-cost metals the oxidation and corrosion resistance usually found only in stainless steels and other high-alloy metals.

It also provides them with an abrasion resistance said to be better than that of stainless steel.

Write in No. 365 on Reader Service Card

UHF FILTER
has tunable cavity

Model 210 aluminum cavity is silver-plated for low loss and pressure-tight to prevent entrance of moisture and dust. The unit covers the frequency range from 200 to 420 mc and has a power rating of 300 W CW, says **Adams-Russell Co., Inc., Dept. S/A, 292 Main St., Cambridge, Mass.**

The cavity has an insertion loss of about 0.5 db, a Q-factor of about 150, and a VXWR (R_o=50) of 1.3. The unit is 9½ in. in diameter by 9 in. high.

Write in No. 366 on Reader Service Card

BERYLLIUM OXIDE
for missile uses

Fabricated, fired-to-shape, and extruded shapes of Berlox beryllium oxide are serving many critical areas in the missile and electronic fields, says **National Beryllia Corp., Dept. S/A, 4501 Dell Ave., North Bergen, N.J.** The high-purity, high-density oxide is being used in nose cones, metal processing, waveguide windows, pyrometer sleeves, electronic tube spacers and envelopes, and other applications.

The material is an excellent electrical insulator with thermal conductivity equal to that of brass. It can be used for temperatures to 4600 deg F and is said to be 1400 times as good as mullite for high temperature electric applications.

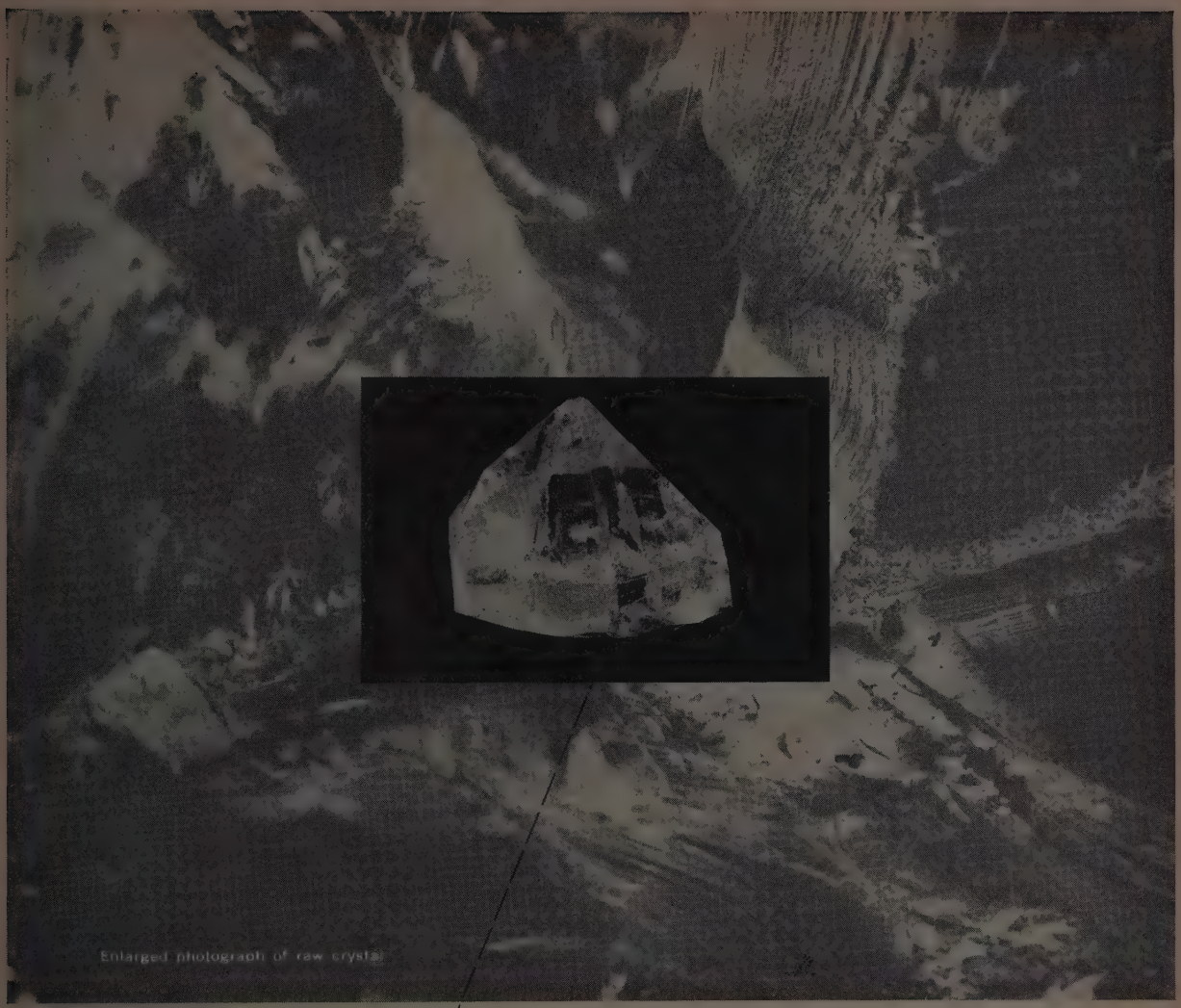
Write in No. 367 on Reader Service Card

TACH GENERATOR
has long brush life

The brushes in this new dc tachometer generator have been rated for over ten years of continuous operation at 3600 rpm, says **Servo-Tek Products Co., Dept. S/A, 1086 Goffle Rd., Hawthorne, N.J.** Voltage linearity is also exceptional: from zero to 12,000 rpm, it is better than 0.1 per cent of the voltage output at 3600 rpm.

In addition to special brush materials, the generator features a commutator fabricated from an alloy containing more than 85 per cent pure silver.

Write in No. 368 on Reader Service Card



BULOVA **CRYSTAL CONTROLLED** VARIABLE FREQUENCY OSCILLATORS

Bulova Crystal Controlled Variable Frequency Oscillators are the *advance* in electronics most engineers have been seeking.

Why? . . . Because Bulova VCF packages combine small size and high repeatability with automatic frequency control or with a variation of nominal frequency by application of external voltage.

The ranges available extend from 10kc to 20mc. Variation at 10kc is up to 6cps, at 20mc up to 12kc. Resolution on these shifts is infinite, it's dependent on stability and resolution of modulating voltage, only. Drift, after stabilization, can be kept to less than 1 pp 10^6.

These unique crystal controlled variable frequency oscillators are only one of many recent advances made by Bulova Electronics. For information on these units, or on how Bulova experience in mastering component and system reliability can help your program, write Department A-1231, today.

BULOVA WATCH COMPANY

ELECTRONICS DIVISION · WOODSIDE 77, NEW YORK

Write in No. 209 on Reader Service Card at start of Product Preview Section

THE U.S. TREASURY SALUTES THE AIRCRAFT INDUSTRY

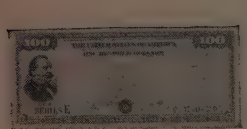
—and its thousands of employees who help strengthen America's Peace Power by buying U.S. Savings Bonds

Men and women who make up the great group who design, fabricate, assemble and test our newest aircraft are also making another substantial contribution to our national security. Many thousands of them are buying U.S. Savings Bonds, regularly, through the Payroll Savings Plan.

Regular purchases of Shares in America help these patriotic and thrift-minded people set up substantial reserves for the education of their children, the buying of new homes and the building of their retirement funds. Through the Payroll Savings Plan the practice of thrift is made easy and automatic.

If your company has not yet put in a Payroll Savings Plan, start now. Your State Savings Bond Director is anxious to help and to show you how easy it is to put the Plan to work. Telephone him now. Or write to Savings Bonds Division, U.S. Treasury Department, Washington, D. C.

L. A. MARTIN, skilled aircraft mechanic, is typical of the thousands of valued employees in this field who are buying U.S. Savings Bonds regularly. Mr. Martin, through his company Payroll Savings Plan, is making a personal contribution to the Peace Power of his country.

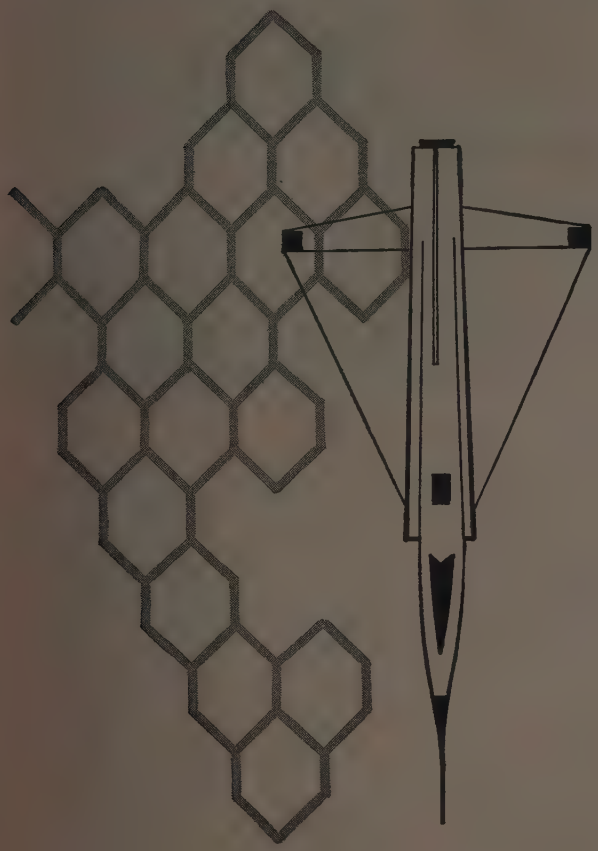


SPACE/AERONAUTICS

THE U. S. GOVERNMENT DOES NOT PAY FOR THIS ADVERTISEMENT. THE TREASURY DEPARTMENT THANKS, FOR THEIR PATRIOTISM, THE ADVERTISING COUNCIL AND THE DONOR ABOVE.

HONEYCOMBS of Armco Stainless Steels Combine

Lightness / High Strength / Resistance to Heat



Armco PH 15-7 Mo and 17-7 PH Stainless Steels provide a unique combination of advantages that enable you to design and produce maximum-performance honeycomb structures. These special aircraft steels:

- **Offer high strength-weight ratios up to 900-1000 F.**
- **Have excellent, minimum room temperature strengths.**
- **Are Available in thin sheets and foil down to .001" thick.**
- **Resist corrosion without plating or painting.**
- **Are fabricated readily by standard production methods.**
- **Yield more aircraft hardware per dollar.**
- **Have been proved by performance.**

For complete information on the properties and fabrication of Armco's Precipitation-Hardening Stainless Steels, fill out and mail the coupon.

ARMCO STEEL CORPORATION
1449 Curtis Street, Middletown, Ohio

Send me design and fabrication data on
☐ Armco PH 15-7 Mo Stainless ☐ Armco 17-7 PH Stainless

NAME_____

COMPANY_____

STREET_____

CITY_____ ZONE____ STATE_____

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

Write in No. 210 on Reader Service Card at start of Product Preview Section

data preview

TUBING—Tolerances, sizes, prices and application information on polytetrafluoroethylene tubing are contained in a four-page brochure available from **Irvington Div., Minnesota Mining and Mfg. Co., Dept. S/A, 900 Bush Ave., St. Paul 6, Minn.** Electrical, mechanical, chemical and thermal properties are also included for the PTFE high-temperature tubing, which is useful in rocket and missile applications.

Write in No. 315 on Reader Service Card

VIDEO RECORDER — Specifications, operational characteristics and design features of a video band magnetic recorder/reproducer have been included in a four-page brochure available from **Mincom Div., Minnesota Mining & Mfg. Co., Dept. S/A, 2049 S. Barrington Ave., Los Angeles 25, Calif.** Presented are color photographs of oscilloscope traces made with the seven-track CV-100, which is capable of reproducing transient phenomena from 400 cps to one mc.

Write in No. 316 on Reader Service Card

THERMAL-RESEARCH—A laboratory for the study of high-temperature problems connected with high-speed aircraft and missiles has been described in a six-page bulletin available from **Chandler-Evans Corp., Dept. S/A, West Hartford 1, Conn.** The Thermo-Research Center is capable of handling fuel flow of 100,000 pph, fuel pressure of 1500 psi, and fuel and ambient temperatures of 500 and 1000 deg F, respectively.

Write in No. 317 on Reader Service Card

DAMPING—The objective measurement of the damping effect of surface coating material for reducing noise and vibration has been discussed in two technical publications by **B & K Instruments, Inc., Dept. S/A, 3044 W. 106th St., Cleveland 11, O.** TR 1 and TR 2, 1958, thoroughly cover techniques and theory for such tests.

Write in No. 318 on Reader Service Card

CASTING—The Minicast process, which combines the basic advantages of investment casting with those of other methods, such as coining, cold-forming and screw machine production, is described in a brochure available from **Casting Engineers, Inc., Dept. S/A, 2323 N. Bosworth Ave., Chicago 14, Ill.** The new process, which is capable of very close tolerances, can produce parts in almost all castable metals and alloys, at production runs up to 50,000 pieces per day.

Write in No. 319 on Reader Service Card

BLIND RIVETS—Engineering drawing and full specifications on the complete line of Pin-Grip hammer driven blind rivets for metal-to-metal and metal-to-wood fastenings are contained in the six-page Catalog 227, available from **Star Expansion Industries Corp., Dept. S/A, Mountainville, N. Y.** A total of 154 sizes are listed in charts covering seven types of fasteners, including full brazier and panel heads.

Write in No. 320 on Reader Service Card

MISSILE MACHINING—The care and precision devoted to the contour machining of missile components are briefly described in a six-page brochure prepared by **Diversey Engineering Co., Dept S/A, 10257 Franklin Ave., Franklin Park, Ill.** illustrations in "Missile Metal Machining" cover some of the intricate contouring operations involved.

Write in No. 321 on Reader Service Card

FACILITIES—A 36-page report on its engineering, research and development, and production facilities has been prepared by **H. I. Thompson Fiber Glass Co., Dept. S/A, 1733 Cordova St., Los Angeles 7, Calif.** Also described are the company's activities in the processing and fabrication of glass fiber, reinforced plastic and structural core materials and products.

Write in No. 322 on Reader Service Card

PHENOLIC FABRIC—Comprehensive technical data on a fiberglass fabric impregnated with V-204, a high-temperature phenolic has been presented in Bulletin 1100 by **Eli Sandman Co., Dept. S/A, 280 Greenwood St., Worchester, Mass.** Resin Ready V-204 may be used in the frabrication of missile components, fuel tanks, antenna housings, air frame structural components, and a variety of other devices, according to the eight-page bulletin.

Write in No. 323 on Reader Service Card

PURE TANTALUM—The application of high-purity tantalum to the electronic, missile, chemical and other industries has been described in a four-page technical folder available from **National Research Corp., Dept. S/A, 70 Memorial Dr., Cambridge 42, Mass.** Chemical analysis, and mechanical and physical properties are included for the tantalum, which features unusual corrosion resistance, exceptional ductility, excellent welding properties, and ease of fabrication and conversion.

Write in No. 324 on Reader Service Card

CIRCUIT BREAKERS—A 32-page technical catalog describing the MP Mini-Breakers line of miniature circuit breakers has been prepared by **Mechanical Products, Inc., Dept. S/A, 1824 River St., Jackson, Mich.** The devices trip in safe time under all normal and transient overloads, incorporate a time lag for start and normal momentary overloads, and permit manual opening of the circuit.

Write in No. 325 on Reader Service Card

WELDING MACHINES—A folder on a new line of arc-welding machines has been prepared by **Harnischfeger Corp., Dept. S/A, Milwaukee 46, Wisc.** Twenty-three models with intermediate ranges from three to 675 amps are available with remote control features and built-in controls for high-frequency, gas, water, and spot gun.

Write in No. 326 on Reader Service Card

FASTENER DESIGN—A 38-page booklet discussing high-tensile fastener design considerations has been published by **Elastic Stop Nut Corp., of America, Dept. S/A, 2330 Vauxhall Rd., Union, N. J.** Design Manual 5825 reproduces NAS and MS bolt specifications, contains cross references for 160,000-, 180,000- and 220,000-psi bolts and compatible stop nuts, and includes a complete set of drawing for the self-locking nut.

Write in No. 327 on Reader Service Card

SPACE ELECTRONICS—The research and development phase of its activities has been emphasized in an initial brochure report by **Space Electronics Corp., Dept. S/A, 1200 Air Way, Glendale 1, Calif.** The eight-page bulletin points out that interests lean toward equipment for instrumentation, ground support, communications, and data transmission, as well as toward other space-related devices.

Write in No. 328 on Reader Service Card

CARBON-GRAPHITE—The eight-page brochure 1164A, which presents the composition, qualities and applications of carbon-graphite for the information of designers, engineers and other interested personnel, is available from **The Ohio Carbon Co., Dept. S/A, 12508 Berea Rd., Cleveland 11, O.** The material, manufactured and machined by Ohio Carbon as Karak, is useful for mold assemblies, pump seals, nozzles, compressor end plates, and a variety of other devices.

Write in No. 329 on Reader Service Card

more on page 276

HOW TO FIND FAULT

...BEFORE COUNTDOWN

...BEFORE TAKEOFF

Just connect your weapon system, manned or unmanned, to one of Autonetics' two automatic checkout centrals: the GS-1A test console or the C6A BACE low-profile cart.

They render a GO or NO-GO verdict in *minutes* instead of hours. They do their critical job at least 100 times faster than a swarm of skilled technicians with meters and hand probes—and they do it with infinitely greater accuracy.

They meet the needs of the majority of modern weapon systems... accommodate adaptive equipment to test special electronic systems.

They're rugged: no relays, no tubes, fully transistorized. They're very simple to use: just show the operator which button to push. They're reliable: continuously take their own pulse.

Autonetics foresaw the day when the electronic systems inside a weapon would become as important as the frame that enclosed them... decided to automate the whole procedure. These automatic checkout controls—originally developed in cooperation with the Air Force and tested in the NAVAHO program—are now at work for both Air Force and Navy.

They're the heart of today's most *versatile* automatic checkout systems—only *practical* way to keep weapon system reliability at a ready-to-go pitch.

Automatic checkout centrals by Autonetics

A DIVISION OF NORTH AMERICAN AVIATION, INC., DOWNEY, CALIFORNIA • REGIONAL OFFICES: WASHINGTON, D. C. AND DAYTON, OHIO

INERTIAL NAVIGATION / ARMAMENT CONTROL / FLIGHT CONTROL / COMPUTERS AND DATA PROCESSING

Now! get complete data on

MINIATURE AGASTAT®

time/delay/relays

This free folder contains complete specs on 24 models of the miniature AGASTAT Time Delay Relay for missile, aircraft, computer, electronic and industrial applications. They're small as 1-13/16" x 4-7/16" x 1½", with adjustable timing ranges starting at .030 and as high as 120 seconds.

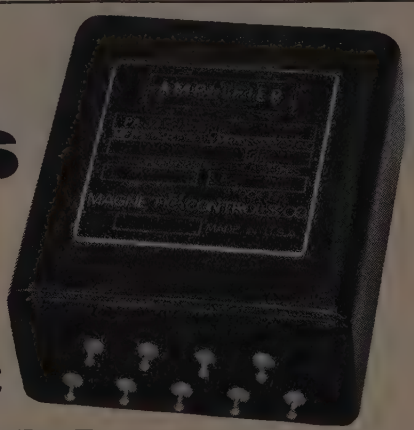
The folder gives operating and environmental specs, coil data, contact capacities, dimensions, diagrams of contact and wiring arrangements. *Write:* Dept. A33-619

AGA DIVISION **ELASTIC STOP NUT CORPORATION OF AMERICA**

Elizabeth, New Jersey

Write in No. 211 on Reader Service Card at start of Product Review Section

500 WATTS IN FIVE CUBIC INCHES!



Shown Actual Size

. . . a brand new proportional amplifier only 5 cubic inches in size and .54 lbs. in weight—for missile, aircraft, and ground equipment applications. A 400 cps, 115 volt proportional temperature control unit using silicon control rectifiers in the output stage, it handles up to 500 watts power. Maximum ambient temperature capability of 100°C!

It's exclusive—available now—and ready to solve your space, weight, and power problems!

Write today for complete information:

MAGNETIC CONTROLS COMPANY

6405 Cambridge Street, Minneapolis 16, Minnesota, Dept. 101

Write in No. 212 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

REPRODUCTIONS—Four time-saving solutions to problems in reproducing engineering drawings are presented in a folder by **Peerless Photo Products, Inc., Dept. S/A, Shoreham, N.Y.** The problems dealt with include copying on opaque paper that is too dense to pass enough light to reproduce satisfactorily on a blueprint or diazo machine.

Write in No. 330 on Reader Service Card

POLYESTER MOLDING—Information on Thermaflow 105, a glass-reinforced polyester molding compound, has been issued by **Atlas Powder Co., Dept. S/A, Wilmington, Del.** Advantages for the designer and molder are discussed.

Write in No. 331 on Reader Service Card

PROCESS CHEMICALS—A data file on process chemicals for metal finishing has been issued by **Allied Research Products, Inc., Dept. S/A, Baltimore, Md.** It includes data on the Iridite chromate conversion coatings.

Write in No. 332 on Reader Service Card

STEELS & ALLOYS—Cards that list 19 special metals used in high temperature applications have been issued by **Allegheny Ludlum Steel Corp., Dept. S/A, Oliver Building, Pittsburgh 22, Pa.** Information includes composition of each alloy, base material, density, rupture strength data, and short time properties.

Write in No. 333 on Reader Service Card

SHOCK TESTERS—Shock testing equipment designed to comply with pulse-defining specifications is described in a bulletin and data sheets by **Barry Controls, Inc., Dept. S/A, 700 Pleasant St., Watertown, Mass.** They are designated Bulletin 57-06B and Data Sheets 1 and 2.

Write in No. 334 on Reader Service Card

CLOSED-CIRCUIT TV—An illustrated bulletin showing typical applications, cameras and housing, pantilt mechanisms, control panels, monitors, and other components has been issued by **Kin Tel Div., Cohu Electronics, Inc., Dept. S/A, 5725 Kearny Villa Road, San Diego 11, Calif.** It is called Catalog No. 6-103.

Write in No. 335 on Reader Service Card

INSULATING TAPES—Bulletins describing CDF woven-glass-base insulating tapes and fabrics have been issued by **Continental Diamond Fibre Corp., Dept. S/A, Newark, Del.** They describe properties and applications.

Write in No. 336 on Reader Service Card

more on page 278

NEED A TAPE WORKHORSE?

"SCOTCH" BRAND Sandwich Tapes

wear longer, cut head maintenance even in digital work

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9578
34916
872271
6355009
74400932
330562217
7703220522
88806111956
437773220071
5662225436662
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77789444003211 9
552278900783006 2
4934006211221 3977
3222734600072441 9
8890026782334110024
4403321907782322 4422
9222473236802741 18034
5687321900333405589226

335066832211 8856723323
4403299967792330011 66
6822003232001 1237787
8300337444323801232
2 1 1 3457888217233 09
5669770032900 8022
9210322431102143
473761670553762
30723881760203
2762030784301
942427750593
63090410782
2490589547
317130273
46302222
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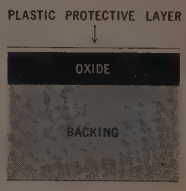
2

Tote that tape—change that reel—clean that head! If your project atmosphere sometimes seems that way, "SCOTCH" BRAND Sandwich Tape comes to the rescue. How about the possibility of getting over 50,000 passes out of a computer tape? And if that sounds attractive, consider the value in a tape that has no rub-off, won't give you any head build-up, drastically reduces maintenance and replacement on costly head assemblies.

One user found that the simple change to "SCOTCH" BRAND Sandwich dramatically reduced head replacements. And—where heads previously had to be cleaned after every run, "SCOTCH" BRAND Sandwich Tape cut cleaning to once a week.

The secret's in the Sandwich—the high potency oxide magnetic coating is sandwiched between the tough polyester base and a thin protective plastic layer. The coating never contacts the head—you get smooth, low-friction tape movement, plus an end to rub-off, head build-up, and a reduction in erosion of the critical slit in the recording head. Though the 50 micro-inch protective layer causes some slight reduction in high frequency response, the plain facts are that Sandwich Tape packs up to 600 pulses per inch in digital work—has broad usage in AM, FM, or PDM applications.



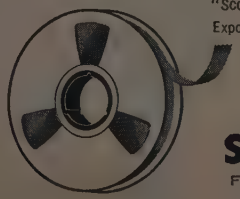
In "SCOTCH" BRAND Sandwich Tape you have a tape workhorse, pulling a big load over long distances. One user reported fewer drop-outs with each successive pass. As his recording heads were cleaned, the contaminates proved to be in the system, not the tape. Speaking of drop-outs, beware the villainous cigarette—often a culprit. One careless gesture and an ash can cause 40 to 60 drop-outs.

Whatever your application — data reduction, acquisition or control programming — count on 3M technology to create tape of higher uniformity and reliability for error-free performance.

"SCOTCH" BRAND High Output Tape No. 128 gives you top output at low frequencies, even under extremes of ambient temperatures. "SCOTCH" BRAND High Resolution Tape No. 159 lets you pack more bits per inch, offers extra playing time. Finally, for top performance at low cost per foot, "SCOTCH" BRAND Instrumentation Tapes Nos. 108 and 109 remain the standard for the industry.

Where there's no margin for error, there's no tape like "SCOTCH" BRAND. For more details, write Magnetic Products Div., 3M Company, St. Paul 6, Minn., or mail the reader inquiry card. © 1959 3M Co.

"SCOTCH" is a registered trademark of 3M Company, St. Paul 6, Minnesota. Export: 99 Park Avenue, New York, N.Y. In Canada: London, Ontario.



REG. U.S. PAT. OFF.
SCOTCH BRAND MAGNETIC TAPE
FOR INSTRUMENTATION

MINNESOTA MINING AND MANUFACTURING COMPANY
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3M COMPANY

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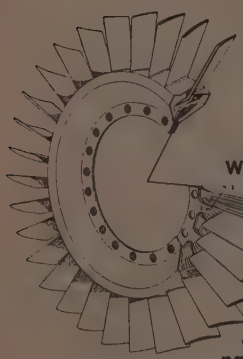
GAS TURBINE

ROTORS

LIGHT IN WEIGHT!

TO CLOSEST TOLERANCES!

LOW COST!



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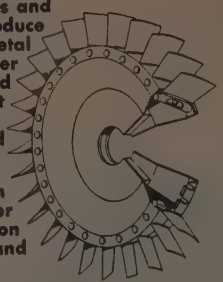

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DATA PREVIEW

GAS SERVO SYSTEM—Design and application to flight control surface actuation of a gas servo system is discussed in Publication GEA-6846 by **General Electric Co., Dept. S/A, Schenectady 5, N.Y.** It also discusses rocket engine thrust vector control and clear control rod actuation.

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ELASTOMERS—Report of studies comparing effects of high aromatic fuels on oil-resistant elastomers is available from **Thiokol Chemical Corp., Dept. S/A, 780 N. Clinton Ave., Trenton 7, N.J.** Tables of data and curves illustrate the effects on volume swell, physical properties and vapor permeability.

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BEARING FITS—Instructions on preventing premature bearing failures and off-schedule removals, procedures on obtaining accurate bearing fits easily and economically, and engineering data assuring perfect bearing fits on all anti-friction bearings, are the subjects of a manual by **Bearing Inspection, Inc., Dept. S/A, 3311 E. Gage Ave., Huntington Park, Calif.** Installation charts are given.

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more on page 280

When the design calls for an indicating gauge, specify the best-
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New catalog covers gauges for every need
MARSH INSTRUMENT CO.
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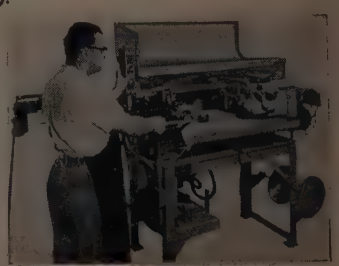
NEW ARTOS TA-20-S
Performs 4 Operations Automatically!

1. Measures and cuts solid or stranded wire 2" to 250" in length.
2. Strips one or both ends of wire from 1/8" to 1".
3. Attaches any prefabricated terminal in strip form to one end of wire. (Model CS-9-AT attaches terminals to BOTH ENDS OF WIRE simultaneously.)
4. Marks finished wire leads with code numbers and letters (optional attachment).

UP TO 3,000 finished pieces per hour. Can be operated by unskilled labor. Easily set up and adjusted to different lengths of wire and stripping. ENGINEERING consultation without obligation. Machines for all types of wire lead finishing.

AGENTS THROUGHOUT THE WORLD



WRITE for FREE Bulletin No. 655 on Artos TA-20-S

ARTOS ENGINEERING CO.
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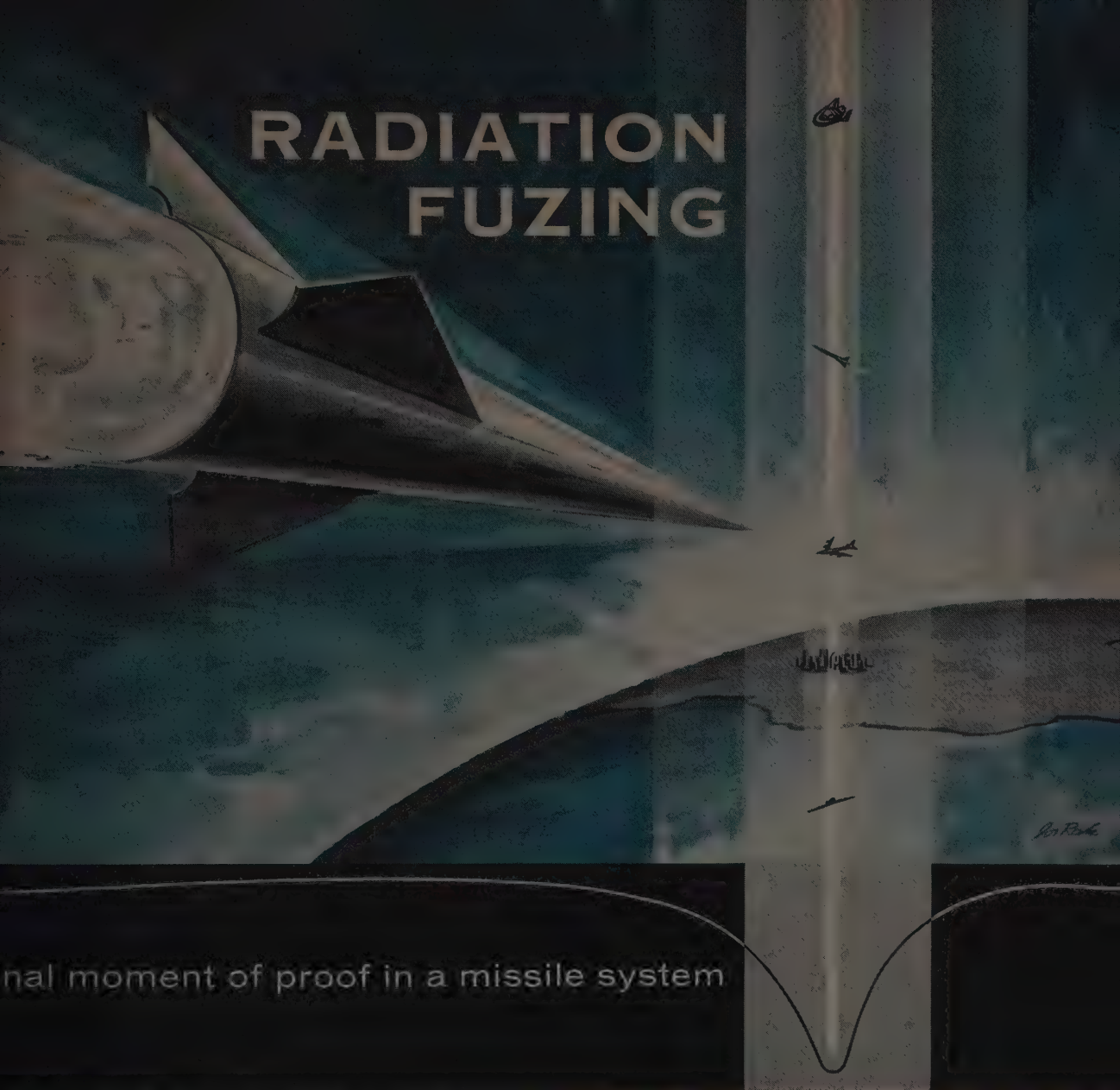

There are hundreds of moments of proof in the life-span of a missile system, but the final, and most dramatic, is that split-second when the radiation fuze fulfills the purpose of the mission. There may be no time for a "second shot".

The critical problems of high closing rates in air and space, of ground and submarine target discrimination and sensitivity, and of improved countermeasures in all areas, demand fuzing techniques which will not fail the technical integrity of the complete missile system. Such fuzes must be subminiaturized and ruggedized to provide absolute reliability and precision under re-entry and other extreme environmental conditions.

The Light Military Electronics Department has experience over a wide range of fuze projects such as mass production of mortar and bomb fuzes . . . COBRA and CORAL fuze development . . . a design study for MAULER . . . advanced Infrared fuzes . . . and a dozen others. Analytical and Development engineering capabilities include:

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For brochure "RADIATION FUZING . . . Final Moment of Proof" or further information on any aspect of fuzing design and development, contact Manager — Missile Sales, Light Military Electronics Department . . . Dept. 11A.

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LIGHT MILITARY ELECTRONICS DEPARTMENT
FRENCH ROAD, UTICA, NEW YORK

A DEPARTMENT IN THE DEFENSE ELECTRONICS DIVISION

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high-energy fuel briefs from Callery

Plenty of HiCal® by August 1, for authorized users—HiCal high-energy fuel production will run well ahead of immediate military test program requirements for the next few months. So Callery will have substantial quantities of HiCal-3 available for authorized users about August 1. If you have been waiting to test HiCal-3 in engines or components, write now for specific information. *New HiCal-3 Handling Bulletin is available on request.*

Lower-cost Diborane from Callery—Production quantities of Diborane are available from Callery at recently reduced prices. Investigations now under way on new process economies will mean even lower prices in the near future.

NASA awards contract to Callery for rocket propellant study—NASA has just announced the Government's first major contract award to Callery Chemical Company for research and development work in the field of rocket propellants. The NASA contract is to determine feasibility of a radically new propellant system.

New HiCal-3 fire-fighting film available for loan—This film shows the relative ease and safety with which a stable mechanical foam blanket can be established over burning HiCal liquid.

Handling of pyrophoric fuels—A new bulletin summarizes safe-handling practices for Triethylborane and Tri-*n*-butylborane. Also available: a 15-minute Triethylborane-Tri-*n*-butylborane fire-fighting film.

R & D on fuels and propellants —Callery's credentials in this demanding field record over ten years of successful studies in fuels and propellants. A limited number of new projects can be handled by Callery now in the area of fuels and propellants, component testing, inorganic and organometallic chemistry. Your inquiry is invited.

Callery to open new office in Los Angeles—Sometime in June, fuel and propellant users in the Los Angeles area can contact Callery's Dr. R. G. Brault, Market Development Engineer, for helpful technical service. Dr. Brault formerly was coordinator of high-energy fuel projects in Callery's R & D program.

For information or loan of films, write to Defense Products Dept., Callery Chemical Company, 9600 Perry Highway, Pittsburgh 37, Pa.

CALLERY CHEMICAL COMPANY

9600 PERRY HIGHWAY PITTSBURGH 37, PENNSYLVANIA

Dr. Robert G. Brault
Market Development Engineer
Defense Products Department
Callery Chemical Company

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DATA PREVIEW

RE-USABLE BATTERY—An illustrated brochure compares the PM Silvercel battery with other battery systems. Issued by **Yardney Electric Corp., Dept. S/A, 40-50 Leonard St., New York, N.Y.**, it discusses applications, electrical characteristics, construction, charging, activation, wet stand, recycling and soaking time.

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INSTRUMENT SENSORS—An information Bulletin describing the "go, no-go" concept of measuring electrical quantities in aircraft and missiles has been issued by **Magnetic Circuit Elements, Inc., Dept. S/A, 3722 Park Place, Montrose, Calif.** Takes up the problems involved in reading dial-type panel meters during missile countdown.

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O-RINGS—O-ring design and application is discussed by **Garlock Packing Co., Dept. S/A, 32 Main St., Palmyra, N.Y.**, in Bulletin AD-148. It discusses materials of construction, dynamic and static applications, use of back-up or non-extrusion rings, and groove design.

Write in No. 350 on Reader Service Card

TEFLON BEARINGS—Bulletin CP-558, covering its Chempro line of filled teflon bearings, has been issued by **Chemical & Power Products, Inc., Dept. S/A, 11 Broadway, New York, N.Y.** These filled materials are suitable for electrical and electronic applications.

Write in No. 351 on Reader Service Card

MINIATURE CLUTCHES—One-way precision roller clutch that allows drive in one direction and freewheeling in the opposite is described in a brochure by **The Miniclutch Co., Dept. S/A, 373 Morse St., Hamden, Conn.** It is called Miniclutch #1.

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BEARING LUBRICANTS—Lubrication of miniature instrument bearings is the subject of a new lubrication manual by **Miniature Precision Bearings, Inc., Dept. S/A, Keene, N. H.** Contains data and information on types and brands of oils and greases.

Write in No. 353 on Reader Service Card

HOSE COUPLINGS—An 8-page illustrated Condensed Catalog No. 34 contains essential information on couplings and fittings for rubber hose. **Hose Accessories Co., Dept. S/A, 2704 N. 17 St., Philadelphia 32, Pa.**, included descriptions of new additions to its line.

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Understandably unwelcome in King Cold's domain . . .

Heating Blankets and other Woven Heating Elements by SAFEWAY can make your COLD problems OLD problems!

Be it the frigid altitudes at which manned aircraft fly, the cold, trackless space domain of missile and satellite, or the icy arctic wastes of DEW Line installations — it's always "winter" somewhere.

Environmental temperature problems common to this kind of "winter" beset fuels and lubricants and hamper the operation of many types of sensitive equipment.

But SAFEWAY dispels such problems by packaging *controlled heat* for application *everywhere*. Among the wide variety of heating blankets and woven-wire heating elements which have been engineered by SAFEWAY to meet exacting specifications are:

- **heating elements for launching equipment and for airborne gyros, cameras, computers, servos and batteries — for missiles or aircraft**
- **de-icing units for airfoil surfaces**
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- **defrosting units for industrial and commercial refrigeration**
- **heating blankets for honeycomb and metal-to-metal bonding**

For your copy of a fact-filled folder, please write:

Safeway HEAT ELEMENTS INC.

600 Newfield Street • Middletown, Connecticut

If it has to be heated (and the "it" can be just about anything), you can rely on SAFEWAY engineers to study your problems carefully, and — without any obligation — submit an appropriate recommendation.

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Italy's role in space flight

by Dr. Glauco Partel
Director, Operations Analysis, Missile Systems Consulting Co.; President, Committee on Terminology & Classification, IFA

IN THE LAST SPACE/AERONAUTICS, I read that the June issue would contain a report on the European space and aeronautic effort.

I am concerned with the space effort, particularly with what is being done in Italy. It was not my intention to talk about this at the present moment, because maybe the time is not yet ripe. However, after considering the pros and cons, I think that what I will discuss here is to the benefit of everybody.

Readers who, by chance, have had the opportunity to peruse the report, "The Next Ten Years in Space," by the U.S. House Committee on Space Exploration & Astronautics, will be aware that in my forecasts I have considered an "international equatorial launching site."

Italy, as such, has neither pretension nor possibility to carry out a space program of her own, and there is no intention to even consider the design and construction of space hardware—at least not now.

However, there is one place where Italy can play a major part and be an "astronautical" intermediate point between the hot sides of East and West spreading into a space race. That's the international equatorial launching site for space vehicles.

Equatorial site is a necessity

Since the Amsterdam Congress of the IAF, where I was a delegate of Italy, talks with American friends and colleagues showed that an equatorial launching site for larger space operations was almost a must. Sooner or later NASA very likely would have to develop such a base.

If you look on the globe, there aren't too many possibilities. One of these is Italian Somaliland, and in particular the area of Chrismaio. It is exactly on the equator.

In the past few months I have written to the competent Italian government departments, pointing out the above situation, and trying to interest them in sponsoring a study to be carried out by Missile Systems Consulting Co., which was formed by international experts and to which directorate I belong.

At the completion of the study, the Italian Foreign Department will submit it to the UN and/or NASA. The Foreign Dept. has written officially to the Defense Dept. for the sponsorship involved.

The proposed study will cover the operational analysis and logistics of the site, available resources and local conditions, political and sociological aspects, as well as comment on competing sites. The proposition doesn't exclude considering an international launching vehicle.

The possibilities offered by the area of Chisimaio for an equatorial launching site are outstanding. An equatorial orbit has: (1) a narrow track over the earth's surface; (2) the best departure point for an interplanetary operation; (3) the capability of all other orbits; (4) a minimum requirement for ground stations and communications systems.

Could be part of 7200-mile course

The Somaliland site adds the following: (1) use of east-directed launchings just over the sea, (2) use of the islands found on a straight-line route over the Indian Ocean for an equatorial orbit and south for a polar orbit, (3) joining over a 7200-mile course (almost on the same parallel) the facilities of the eventual U.S. equatorial launching base at Manus Island, to provide the greatest range in the world. Somaliland also offers the advantage of weather permitting launchings throughout the year.

Connecting America to Europe by automatic postal rockets requires first creating a collection mail net both in Europe and the U.S. For the European collection net, ramjet vehicles are seen. Rome, Vienna, Berlin, Stockholm, London and Paris will be connected. Paris, say, might be the European main postal center.

A similar net will be formed in the U.S. The frequency of vehicles per day requires accurate operational analysis as well as statistical study.

Ramjet flight times of 20 minutes

Flight times of ramjets are to be on the order of 20 minutes. Now if we take, for instance, a frequency of one vehicle every half-hour and add 15 minutes for transfer of mail from the main post office downtown to the launch site, mail in the worst case will take an hour and five minutes from main office to the launch site in Paris. For internal European service, mail will take 80 minutes from the post office of one town to the post office of another.

Between Paris and the main center in, say, New York, a rocket glider will take about an hour. In the

worst case, therefore, mail from the post office of a European town will take 164 minutes to reach the American site, assuming a frequency of one vehicle per hour.

Payload of the trans-Atlantic vehicles will be 20-100 kg (44-220 lb). European vehicle payloads will be 5-10 kg (11-22 lb).

The vehicles would be guided by electronic systems. Guidance of postal rocket vehicles will be easier than that of war missiles, since ground equipment can be installed in the locality that corresponds to the target of the missile.

A design of this type is under study by Dr. Angeloni and the author. SISPRE, a study group sponsored by the Italian industry and the armed forces, has shown interest in it.

SISPRE has developed a sounding rocket design for high altitude research. The Italian government is financing it. It is a two-stage craft with solid propellant engines. It takes a payload of about 50 lb to the first layer of the F-region of the atmosphere.

Tracking station should be set up, too

A proper connection of this development with the whole sounding program of NASA could speed up research in this field. A tracking station should be set up at the same time (studies have shown that a complete station could be built in Italy by the local industry at $200,000 less than what it would cost if built in the U.S.).

A sounding program specially conceived for the equator is most advisable. The meteorological data it would gather will allow, for instance, the realization of the "equatorial glider."—End

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Contributions to this department may be on any subject, technical or nontechnical, about which readers would like to air their views. Names and professional affiliations will be withheld on request.

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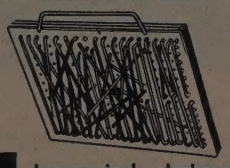
DIT-MCO's exclusive cross-reference Matrix Chart automatically pinpoints each circuit flaw and puts clear, concise test information directly in front of the operator! Horizontal and vertical indicator lights cross-reference on the matrix square corresponding to the circuit under test. This square details type of flaw, circuit number and exact error location. Once an error is detected, the operator immediately marks it on the matrix square, resets the Universal Automatic Circuit Analyzer and continues the test.

All corrections are made direct from the Matrix Chart after the test sequence has been completed. This saves up to 90% correction time by eliminating time consuming searches through diagrams, manuals or interpretive readout devices. Because the DIT-MCO Matrix Chart is a simple, concise representation of all test circuits, specifications, instructions and modifications, *nothing* is left to chance or guesswork! The comprehensive nature of the Matrix Chart system provides important data for statistical analysis and permits *effective* checks and balances . . . from the drafting board to obsolescence!

DIT-MCO, Inc. employs an experienced staff of sales engineers in the field. Contact your field engineer or write for important facts about DIT-MCO Electrical Test Equipment.



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Jumper-wired plugboard programming utilizes simple, straight-forward adapter cables. Circuit modification problems vanish because all changes are easily made by re-jumpering the readily accessible plugboards.

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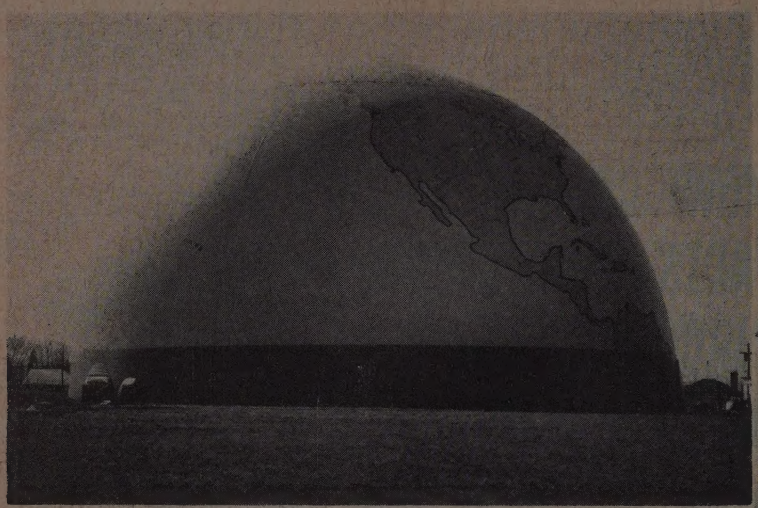
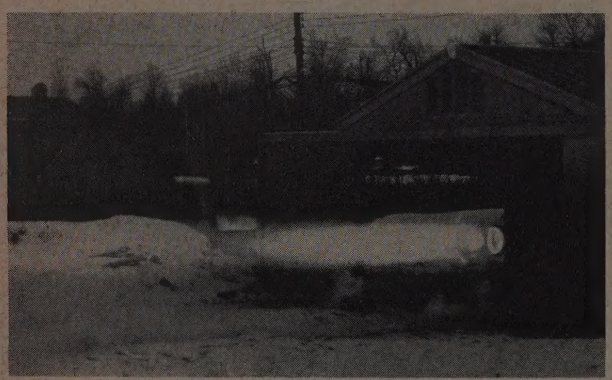
industry briefs



ARMY MISSILES will be maintained in this five-story-high Pentadome designed by Birdair Structures, of Buffalo. The 150-ft-diameter dome encloses 17,500 sq ft of surface area. Four hemispheric, 100-ft-diameter shelters will be added to it.

U.S. ORDER for French Nord SS-11 antitank missile was revealed. The wire-guided weapon has a solid rocket and can be fired from the ground as well as from copters.

▼



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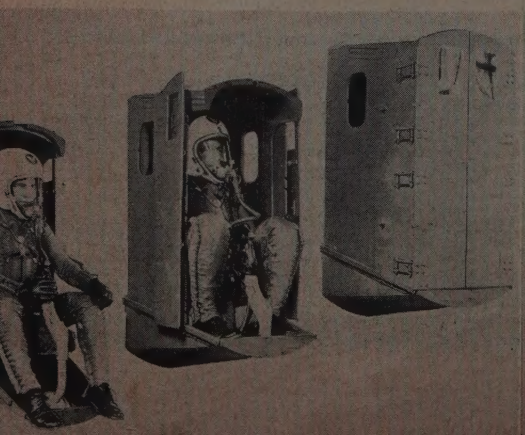
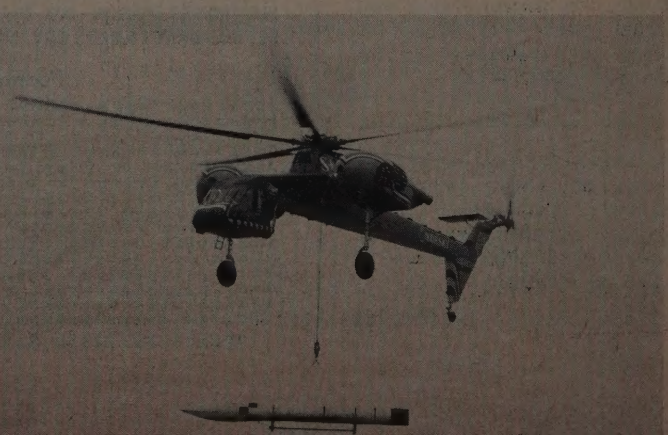
FIRST released photo of a large rocket chamber burning liquid fluorine was taken at Bell Aircraft's Niagara Falls, N. Y., facilities. Bell has just received an NASA contract for work on the use of fluorine together with various fuels.

PILOT can escape from Mach 2-3 planes as well as satellites in this capsule, designed by Republic, which closes up around him in less than two seconds.



NEW Sikorsky S-60 crane copter, with two P&WA R2800 engines of 2100 hp each, can carry 4-6 tons over 100 miles. It is designed for conversion to turbine power.



From an original painting for CECO by R. T. Handville

KAMAN'S H-43B HUSKIE is powered by a Lycoming T-53 gas turbine with complete, single-package *fuel control and pumping system* engineered and precision-produced by Chandler Evans.

CECO's product in the Huskie is one of a number of "unitized" control systems developed expressly for the fast-growing small engine field. In addition to controls for application in manned aircraft, other lightweight, compact CECO engine control systems have been developed for target drones and missiles, while still others are available for auxiliary power units in airborne and ground support systems.

Chandler Evans *pioneered* single-package design of formerly separate fuel system components and today enjoys a position of leadership in the field of small engine fuel control and pumping systems.

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Interesting, informative literature on many CECO products is yours for the asking. Please address your request to Dept. 39.

CECO
SYSTEMS
CONTROLS

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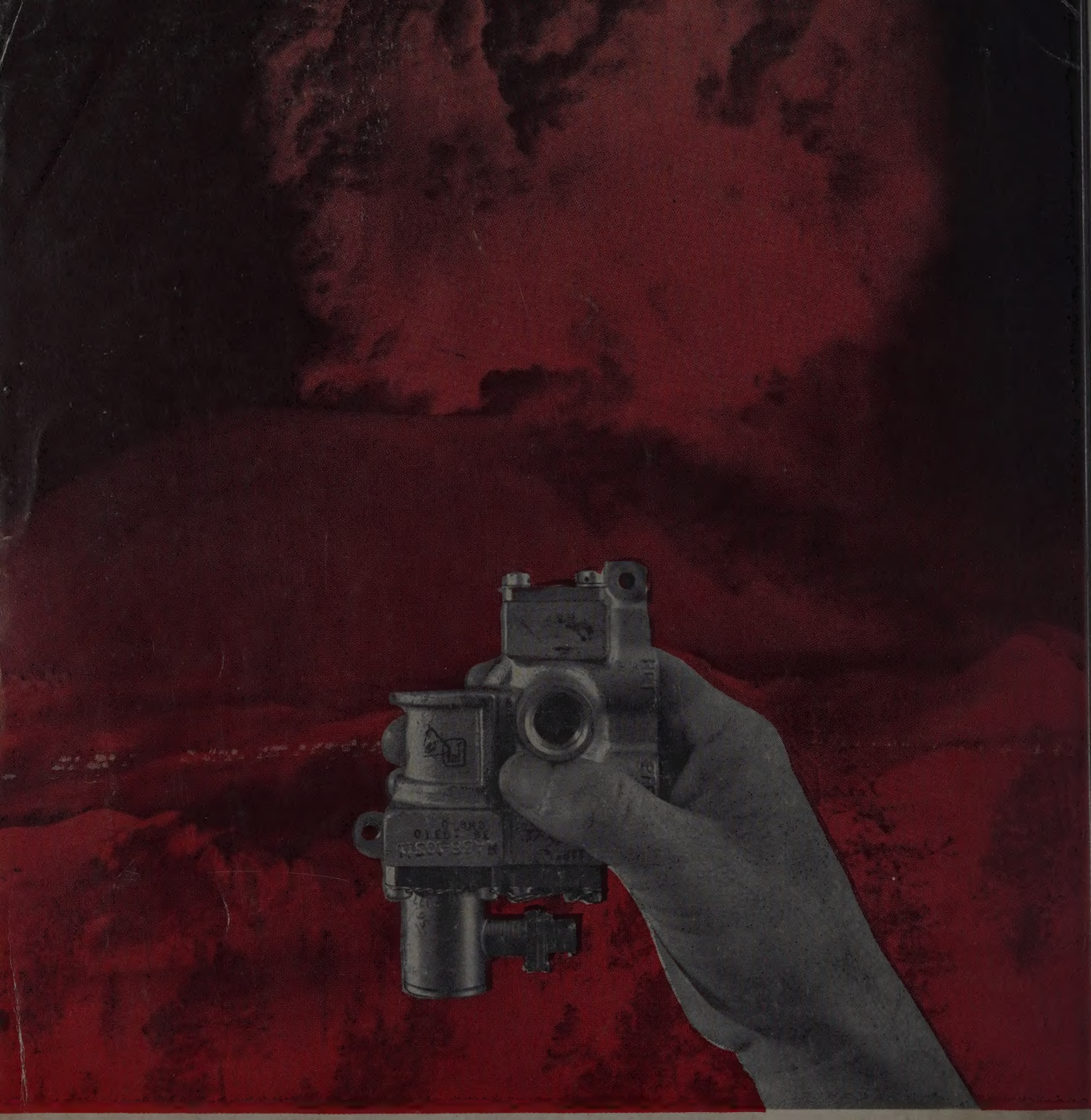

High temperature hydraulics

In 1943 Hydro-Aire built its first hydraulic valve. More than 100,000 valves and controls have since followed this initial contribution to airborne hydraulic systems. Put them all together and they could well handle the output of an active volcano.

Today's requirements for high temperature, high flow and high pressure hydraulic controls call for new ingenuity and new capabilities. To meet this demand, Hydro-Aire has combined its experience in high temperature pneumatic controls and high flow fuel system controls with its considerable experience in hydraulics. The result: a unique combination of capabilities and manufacturing know-how to meet the need for complex miniaturized hydraulic controls that will function with fluid temperatures of 450°F, 700°F ambient temperature, and under pressures in the 4,000-5,000 PSI range.

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BURBANK, CALIFORNIA
Division of CRANE CO.
Anti-Skid Braking Systems • Fuel System Controls • Pneumatic Controls • Hydraulic Controls Actuation Systems • Electronic Devices

Producing Controls for Every Basic Airborne System

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